

FORESTS IN RELATION TO CLIMATE, WATER CONSERVATION AND EROSION.

Extracts from the Proceedings of the
British Empire Forestry Conference,
South Africa, 1935.



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PREFACE.

THE report of the Committee appointed by the Empire Forestry Conference in South Africa, and the debate on forests in relation to climate, water conservation and erosion, as well as the paper presented by India to this conference, form such an important contribution to this well-known and much discussed subject that it has been considered necessary to give them the widest publicity in India. The gentlemen comprising the committee represent the considered opinion of forest officers in every part of the world ; and the contributions to the debate by officers of great experience illustrate, by examples known to them personally, the great degradation in the surface of the earth wrought by forest destruction, excessive grazing and erosion. Erosion is an evil of comparatively slow growth but none the less is one of the major evils of the world today. Almost anywhere in India its consequences may be seen. Especially in the drier parts, where water is the life of the countryside, does this evil increase and spread desolation in its wake. The damage done by floods recurs annually in India, but few consider whether any steps can be taken to mitigate these disasters by natural means and at an expense infinitesimal as compared to engineering works. People look on while the villager destroys the forest on whose welfare he depends ; unmindful of what befalls his posterity. The Forester can only point the way, policy is a matter for peoples and Governments and if the following extracts can only excite some interest among the intelligent public of India the labour devoted to this work will not have been in vain.

GERALD TREVOR,

*Inspector General of Forests
to the Government of India.*

REPORT OF THE COMMITTEE ON FORESTS IN RELATION TO CLIMATE, WATER CONSERVATION AND EROSION.

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INTRODUCTION.

The Committee was appointed at the special request of the Minister for Agriculture and Forestry and was directed to inquire into the whole question of forest influence, i.e., the effect of forests on climate, water conservation, and erosion, with special reference to South Africa, and the establishment in that country of forests of exotic species.

Obviously a general conference of this nature, following a rigid itinerary and arranged to permit a survey of the whole field of forestry activities in a period of between five and six weeks only, could not enter sufficiently into time or adapt to travelling facilities for an exhaustive investigation of the highly important subject of forest influence. Hence, the Committee itself and the Conference as a

whole embrace members who for many years have had the subject under constant review, and who are therefore competent to treat the matter with some degree of authority. Secondly, we have had at our disposal a wealth of literature dealing with the subject, not only in countries comprising the British Empire, but also in other countries which from time to time have been faced with acute conditions of the same problem. Thirdly, anticipating that the subject was one to which special attention would be given by the Conference, some of the forest authorities who are participating in the Conference presented specific statements treating the subject in great detail. Fourthly, the subject was fully debated at plenary sessions of the Conference, and we would point out that the members of the Conference represent almost every part of the British Empire, every climate and major type of vegetation which occurs in nature, from arctic to tropical, from northern coniferous forest to mangrove swamp or thorn forest. Fifthly, we have had the advantage of lengthy interviews with laymen and experts who have given the subject a great deal of consideration and investigation; in this category are the several engineers, botanists, agricultural officers, wattle growers and farmers who have appeared before the Committee. These included Mr. van Reenen, Chairman of the Irrigation Commission, Mr. Lewis, Director of Irrigation, Mr. W. R. Thompson, University of Pretoria, and Professor Philips of the Witwatersrand University, who, in addition to presenting his views verbally to the Committee, handed in a memorandum containing useful information on the subject.

It is upon these grounds that we submit a report in which we have endeavoured to treat the subject in a non-partisan spirit and with a due sense of the complexity of the problems involved.

In view of the value of much of the information presented to the Conference, we attach to this Report, for the consideration of the Government of the Union of South Africa, the verbatim report of the debate on the subject, and we would particularly refer to the summing up of the debate by the Chairman of the Committee.

We desire to emphasise the fact that the subject is of vital importance, not only to South Africa, but to all other countries of the Empire, indeed to the world at large.

I. FORESTS AND CLIMATE.

(a) *Preliminary Remarks.*

The influence which forests have upon climate has been the subject of investigation for a great many years. Also, it has on numerous occasions been the cause of heated and at times quite unreasoned controversy. As so often happens when there are inadequate scientific data for the settlement of a technical problem

people divide themselves into opposite camps taking extreme views and giving vent to dogmatic assertions which cannot be justified by the facts available. The reaction of such extremist statements upon the public mind is most unfortunate, and often in the heat of controversy the main issues become obscured.

In a field where there is still so much to be learned and so many scientific facts to be established, it is hardly to be expected that we can, in the short time at our disposal, set forth completely and finally the effects of forests upon climate. In the ensuing pages, however, building upon the information at our disposal, we have made an effort to present the facts as they appear to us.

In dealing generally with the question of forests and climate (and the same applies in regard to the influence of forests in other directions), we wish to emphasise the fact that under the term "forests" we do not include mere patches of exotic plantations or small isolated areas of indigenous wood. Rather, we define as forests the more extensive areas of tree-covered land, whether of natural forests such as the indigenous woods of the Knyena region, or of large blocks of plantations, as in the afforested districts of the Eastern Transvaal.

With these preliminary remarks, we will now deal with the relations between forests and climate and in doing so, the effects of forests upon the several factors of climate will be considered.

(b) *Temperature.*

The physiological and physical processes attendant upon plant growth reduce the temperature of the air; firstly, because plants transpire water, and secondly, because the sun's heat is absorbed in the process of evaporation. By reason of its composition the living plant substance cannot become heated to the same extent as bare rock or soil. Moreover, the ground under plants cannot become greatly heated by the sun's rays owing to the interception of the latter by the canopy of vegetation. It follows that the effect of forests during the growing season is to lower the temperature of the air in and above them and, by reducing the absorption of heat by the earth's surface, to lower the soil temperature and correspondingly reduce evaporation. Observations have also shown that forests not only moderate the extremes of heat in summer, but that as a general rule they also modify the extremes of cold in winter. Keeping in mind the fact that it is at the maximum and minimum extremes of temperature that the more serious damage from heat and cold occurs it is patent that, apart from any benefits which may accrue from forests in other directions, their effects upon the temperature of a region are highly beneficial to man and beast.

(c) *Wind.*

By diminishing the velocity of winds forests decrease evaporation and wind erosion. Except in so far as very extensive forests may enrich with moisture the air-currents which pass over and through them, it cannot be said that they exert any great or general effect upon the broad continental air-currents.

Locally, however, forests do exercise a very beneficial effect in ameliorating the severity of winds by virtue of the mechanical obstruction they offer, and the uses made of forests and even of mere patches of woodlands or shelter belts, for the protection of buildings and lands are universally known.

It is therefore unnecessary to do more than state the fact that the influence of forests in modifying the adverse effect of winds is wholly beneficial.

(d) *Rainfall.*

After careful review of the data available, we are of opinion that at various times and in different countries, altogether too much credence has been placed in the supposed influence of forests in increasing the total rainfall of a country. We can find no reliable evidence to this effect and would point out that the topographical features of a country exercise a far greater influence upon precipitation than can be exerted by forests alone, however vast. On the other hand, there is evidence to show that forests have some influence upon the local distribution of rainfall, by lowering the temperature of moisture-laden winds, and in other ways, and we affirm that from this view-point a judicious distribution of forests throughout a country is highly beneficial.

(e) *Atmospheric Humidity.*

Under a leafy canopy, the humidity of the air is higher in the forest than in the open. The process of transpiration of itself increases the moisture content of the air within and near the forest; also the temperature of the air within the forest is lower, and consequently nearer the saturation point. Under the influence of these two factors, manifestly the influence of forests is to increase relative humidity.

(f) *Evaporation.*

Experiments extending over a great many years have demonstrated that the evaporation from soils within the forest is less than in the open. The greater the wind, the higher the temperature, and the lower the relative humidity, the greater must be the evaporation from the soil; consequently, the forest, by reducing the velocity of winds at the surface, by reducing the temperature, and by increasing relative humidity, necessarily retards evaporation.

Experiments have also shown that the evaporation from free-water surfaces is less within the forest than in the open. The same

factors which operate to reduce evaporation from forest soils also operate to retard evaporation from free water surfaces within the forest.

Within the forest, the extent of evaporation from the soil varies with the character of the vegetation and particularly with the nature of the ground litter. Some trees intercept the sun's rays much more effectively than others; some species form a litter that retards evaporation more effectively than do others. Whatever the degree of effectiveness of various tree species in this direction, however, all forests tend to retard evaporation from the surface layers of the soil.

(g) General.

Climate, being a combination of all the above factors, has without doubt seriously deteriorated over large portions of the earth by reason of the destruction of the forest. While afforestation may have only slight bearing on the climatic conditions of a country, the progressive destruction and degradation of vast areas of natural forest result in increasing aridity, the desiccation of the soil and the impoverishment of mankind. We wish to draw attention to Mr. Ainslie's memorandum, which summarises the views of the greatest authorities on West Africa, and especially to the statement of Migeod that the Gaboon is becoming the graveyard of the dying races of Central Africa, dying because of the degradation of the land they inhabit. Mr. Trevor also has drawn attention to the decay of the Asiatic Empires and to the poverty of peoples who inhabit what were once the fairest portions of the earth.

We have tried to make it clear that the climate in general of a continent or broad region is something which is determined very largely by extraneous factors. It has often been either stated or implied that the absolute climatic factors, temperature, wind, and rainfall, are the result of solar and terrestrial conditions which man cannot alter. We have pointed to the fact, however, that by exercising judicious control of the vegetative cover, man can modify the effect of absolute climatic factors and so lessen appreciably the detrimental results to which those factors may give rise.

We have no positive proof that during the present era South Africa was to a large extent forested. We do know, however, that within historic times there was a much greater area of natural forest than now exists; we know also that the condition of such forest was far better than it is at the present day. Even assuming that 500 years ago the area now comprising the Union of South Africa was not forested to the same extent as other lands, we do know that the development of the country since the ingress of the white man has been attended by serious depletion of the indigenous forest.

Manifestly we are not in a position to prove that this disturbance of natural conditions has had any appreciable effect upon climatic

factors in the absolute sense, we may even doubt that it has. But we do believe, and we shall later seek to establish, that the disturbance of natural conditions has had disastrous effects in other directions.

Such being the case, and taking into consideration the beneficial effects which forests have in ameliorating the untoward results of climatic factors, we cannot do otherwise than commend any and all efforts which are being made, or which can be made, to bring under forest cover a greater proportion of the land area of the Union. Whether or not such extension of forests should be by increase in the area of exotic plantations or by the extension of the area occupied by indigenous species, is for the moment beside the question.

II. FORESTS AND WATER CONSERVATION.

(a) *Preliminary Remarks.*

Apart from their utility in the supplying of wood products, some of the most beneficial effects of forests lie in their influence in conserving the supply of water for natural springs and reservoirs, and in regulating the flow of streams and rivers. In very few parts of the world is there a reasonably uniform distribution of rainfall. Practically all countries experience definite seasons when precipitation is heavier than at other times. Water being one of the things most vital to animal and vegetable life, the effort of man from time immemorial has been to conserve it and put it to use in such places and at such times as his cultural and industrial pursuits have demanded. It is a sad commentary upon man's efforts in this direction that the earlier civilizations started their conservation works at the wrong end. One of the reasons for the decay of the great irrigation works of Mesopotamia, the ruins of which far surpass any similar undertakings of to-day, was the neglect or inability to control the catchment areas of the Tigris and Euphrates. The control of water supplies must follow natural laws, and it is only in comparatively recent times that this fundamental fact has been realised; even now the attention given to the conservation of catchment areas is wholly inadequate.

In life as we know it to-day, one of the main activities of man is to arrest the flow of waters and put them to the greatest possible use before they descend to the seas—for the watering of farm lands by irrigation or otherwise, for the development of hydro-electric power, for the needs of urban and rural communities, for the purpose of navigation, and for similar objects.

It has been held that engineering works constitute the proper means for the regulation of water supply. This is true only to a certain extent. Engineering works cannot take the place of nature; rather, they should be used to supplement and augment her provisions.

It is easily demonstrable that forests play a highly important rôle in the conservation of water and regulation of its flow. Almost every forester can recall a woodland spring that upon removal or serious disturbance of the forest was dried up, and the majority of people can cite instances of the partial or total drying up of water courses, resulting from the same cause.

(b) *Run-off.*

It is impossible to divorce water conservation from climate. The first influence of the destruction of the forests is on the moisture content of the land, the diminution of perennial streams, the increase of floods, the deposit of detritus by wind or water, and the gradual reduction of cultivation. All this is followed by increasing aridity, by the greater desiccating effect of wind, by increasing severity of climate, until the land will no longer support a wealthy and prosperous population. Poverty grows with the deterioration of the land until the time arrives when man departs leaving a desert behind him.

Proceeding now to consider in detail the actual effect of forest on various aspects of water conservation.

Mr. A. D. Lewis, Director of Irrigation, divides the uses to which water is put as follows :—

- (1) navigation ;
- (2) water power ;
- (3) industrial and municipal uses ;
- (4) watering of stock ;
- (5) irrigation ;

to which we would add agricultural and forest crop production.

As regards *navigation*, while this matter is of no consequence in South Africa, Mr. Galbraith in his speech gave a specific instance where the destruction of forest in Australia had resulted in rendering a river unfit for navigation. Many Indian rivers previously navigable by ocean-going sailing ships can now only be navigated by canoes or similar craft. This deterioration is due to the silting of their channels by eroded material from the hills.

Water power may not be of much consequence in South Africa but in other parts of the world is of great importance. We have been told of cases where a somewhat precarious water supply was increased by the afforestation of the catchment area of the stream and the figures obtained from experiments conducted in the Appalachian Mountains and the White Mountains, U.S.A., at Emmenthal, Switzerland, and in the Cevennes, France, prove the more equable flow of water from a forested than from a disforested area.

As regards *industrial and municipal uses*, Mr. Lewis considers these requirements insignificant when compared with the total water resources of South Africa.

We may observe that the experience of all other countries is that catchment areas for such uses are best maintained under forest, and we would recommend here that all important catchment areas throughout the Empire should be placed under sound forest management.

Mr. Lewis proceeds to deal with water required for *irrigation and for watering stock*, and shows that over large areas of 40 in. rainfall country extending along the South and East Coasts, the Drakensberg in Natal and Transvaal, and parts of the Zoutpansberg, afforestation, even if it did decrease run-off, would have no injurious effect on any interests and would utilise some of the surplus water which otherwise would flow to the ocean. In the case of reservoirs and dams the influence of a forest cover in the catchment areas would be beneficial by decreasing run-off and preventing silting; these benefits would outweigh any possible adverse effect on the controllable water supplies. In particular the mechanical obstruction of several layers of foliage, by breaking the force of the very heavy storms which often occur at the beginning of the rains, plays a very great part in reducing the rate of flow and so reducing the silt-carrying capacity of the water.

This question of silting has been causing the greatest anxiety to engineers; the rapidity of silting on denuded catchment areas has often exceeded the professional estimates and has rendered many of these undertakings entirely unprofitable. Irrigation engineers in India are apprehensive on account of the decreasing winter supplies of water and of the increasing number and severity of floods. It has also been proved that silt-laden water does not penetrate into the soil and therefore largely runs to waste. There is overwhelming evidence that forests have a regulating effect on stream flow, decreasing floods and increasing the flow of water at dry times of the year when streams from a disforested area dry up altogether.

(c) *Springs and Natural Reservoirs.*

In the last section the effect of forests on run-off and stream flow were considered. We shall deal here with the effect of forests on springs and underground water.

It is often stated that the natural forest, or even the natural veld, are better conservers of moisture than plantations of exotics. Even if this were so, it may be pointed out that, for practical purposes, land under plantations should not be compared with natural veld because the activities of mankind seldom permit of the veld being maintained in that ideal condition.

Mr. Carlson in dealing with this subject remarked that perhaps the fact had been overlooked that the natural forest was composed

of a variety of species producing a highly absorbent soil; he advocated mixed crops of trees both for the better moisture conservation of the soil and for the production of timber of better quality. There is every reason to suppose that in the next rotation in South Africa many of the plantations will be regenerated naturally, will contain a greater mixture of trees, including indigenous species, which are already making their appearance in the plantations, and will so approach more nearly the character of natural forest. The Forest Department of South Africa is equally alive to this matter and has no desire to convert natural forest into plantation, but is making every endeavour to preserve and improve all areas of natural forest under their jurisdiction.

In general it may be accepted that forests use up a certain amount of soil moisture and, in areas of low rainfall, may exercise a draining influence on the soil. Some eucalypts have a pronounced action in this respect and have been used for the draining of swamps. We have no reliable information as to how deep this action goes, but we consider it unlikely that it goes much below the depth to which the mass of the feeding roots penetrate, that is, to a few feet at most. We can find no reliable evidence to show that the subsoil water level is lowered by planting trees or that they have any effect on deep-seated springs or on the water table; their action appears to be confined to water on or near the surface, much of which would in any case run to waste on a denuded catchment area. South Africa, as may be seen from a recent publication on the subject*, is at present passing through a series of years of diminished rainfall, and this must have far greater influence on water supply than tree planting.

Researches by Burger and others show that forests allow rain to penetrate into the soil, thereby feeding deep-seated springs. This penetration is due to the fact that forest soil, mainly owing to the action of tree roots which ramify through it, is far more porous than soil of identical origin in the open. The presence of a layer of spongy humus or a mass of needles and undecomposed vegetable matter also contributes to the absorption of water and the prevention of run-off, but it is now recognised that the absorptive capacity of humus is of less importance than that of the forest soil itself.

The draining effect of forest is most pronounced on level ground where swamps tend to form. On hillsides any action which may be considered deleterious to water conservation is far more than counter-balanced by the beneficial action of forests in mechanically obstructing the run-off and increasing the porosity of the soil.

In the course of our visits to some of the afforested areas in South Africa, we have received complaints from representatives of the farming community to the effect that the planting up of

* 'A Study of South African Rainfall', by Messrs. Schumann and Thompson.

catchment areas with fast growing eucalypts and pines had diminished the water supply, sometimes to the extent of causing a cessation of flow in streams which were once perennial. Emphasis was laid in particular on the danger of planting such trees in the neighbourhood of streams, which are alleged to dry up as a result. We would point out in the first place that this is at variance with the generally accepted conclusions regarding the effect of forests on streamflow and secondly we have the assurance that in many areas where no afforestation has taken place a similar diminution in streamflow has occurred in recent years. Furthermore in Australia, under climatic conditions very similar to those of South Africa, the policy of water conservation boards is to protect strictly the Eucalypt forest on their catchment areas.

All things considered, we are not disposed to place much credence in the complaints instanced above, but we suggest that a comprehensive scientific investigation on the effects of tree-planting upon local water supplies would be of value not only to South Africa, but also to other parts of the Empire. Such an investigation, however, is likely to take many years before yielding definite results. In the meantime we suggest that where the question of water conservation is a vital matter, it would be advisable, in order to allay public anxiety, not to plant fast-growing exotics at the actual sources of streams and the eyes of springs; in such places the natural vegetation should be carefully protected. We understand that the Forest Department is already acting on these lines.

In conclusion, we wish to state that, having carefully weighed all the considerations and evidence available, we do not consider that the afforestation policy of the Government of the Union has been detrimental to the general water supply of the country.

III. EROSION.

It is unnecessary for us to recapitulate all that has been stated on this aspect of the subject during the debate. It is admitted by all authorities on erosion that one of the greatest calamities which have overtaken mankind has been the destruction of the forest and the consequent erosion of the land surface. This has already destroyed the fertility of many lands and is at the present day exercising a powerful influence on the destiny of peoples.

Erosion results from the misuse of the surface covering of the earth, whether it be by the destruction of the forest which covered it, by the misuse of arable or pasture land, by bad methods of cultivation, by burning or by overgrazing. We are chiefly concerned here with the influence of the forest. Erosion caused by faulty methods of cultivation or pasture management we leave to, the sister science of agriculture; indeed the Drought Commission has pointed out that faulty pasture management in South Africa

is at the present day the greatest factor in causing erosion. Nevertheless in dealing with the erosion problem the planting of trees can be as beneficial in South Africa as in other countries confronted with the same problem. Erosion is worse in countries of low rainfall and hot summers than where an ample rainfall covers immediately any bare surface with vegetation. The conflagrations which rage throughout the savannah forests of Africa gradually end in their destruction. The heat of the sun, hot winds and the trampling of stock pulverise the surface soil, which is then blown away by the wind or washed away by the torrential downpours which generally follow prolonged periods of drought. In this way the whole top soil may gradually be eroded away in the form of sheet-erosion, leaving an unfertile sub-soil from which man can at the best eke out a miserable existence. Thus the destruction of the savannah forest leads imperceptibly to the desert which can support neither man nor beast.

The geological formation exercises a powerful influence on the rapidity of erosion. Once denuded of their natural covering, land such as the tertiary formations of the outer Himalaya and the red earths of Africa are eroded with appalling rapidity; likewise the loess plains of the prairie provinces of North America are rapidly ruined by sheet erosion and gulying; so much so that large areas of cultivated land have been abandoned as impossible of repair, and the sky for many hundreds of miles in North America has been darkened by clouds of top soil being blown from farms of the prairie region. The illustrations in the papers submitted to the Conference and to be found in any work dealing with this subject will show how a land surface is utterly destroyed by gulying caused by the rush of water on a denuded soil. There is evidence, however, from all over the world that even where erosion, especially sheet erosion, has actually commenced, it is possible to remedy the position by preserving the natural vegetation and by afforestation.

Where extensive gulying is already present, afforestation must be combined with engineering operations of a minor nature such as the construction of small dams, fascines, etc. The combination of such engineering operations with the protection of the soil from burning and grazing, together with afforestation, can deal with the problem.

Statements have been made in South Africa that wattles and eucalypts promote erosion. This is entirely contrary to fact so far as the Government and large private plantations under proper management are concerned. All these plantations are covered with a thick layer of vegetable detritus, and, in the case of wattles the piling of the brushwood in contour lines subsequent to clear felling entirely prevents soil erosion. Nowhere have we seen the least indication of erosion in these plantations, nor is the

ground bare of cover except on fire lines which are rightly swept clean of all such material as a precaution against fire.

We must repeat that too often the erosion problem is considered from the wrong end, and large engineering works are conceived for the mitigation of this evil, whereas the problem should be tackled at its source in the hills, and cured by the generally inexpensive measures of nature rather than by the costly constructions of mankind.

Enough, we consider, has been said during the discussion of this subject to point out the beneficial effect of the forest as a natural cover of the surface of the earth and of the disastrous results of the destruction of such cover. Whether it be on the mountains of the Himalayas, the highlands of Australia, the savannah forest of Africa or the plains of North America, wind and water, unrestrained, exercise their powers of disintegration on the denuded surface of the earth, ruining land laboriously prepared for the satisfaction of the needs of mankind and rendering once fertile areas sterile and uninhabitable.

IV. GRASSLAND BURNING.

Although we have been asked to give our views on this subject, as foresters we are more immediately concerned with the forest than with the veld. However, this problem of veld burning cannot be considered as entirely one of agricultural importance. The vast fires which rage over the greater part of Africa have resulted in an ecological retrogression from forest, savannah, and scrub to grass ending on the southern edges of the Sahara in the extension of the desert. Thus fire, along with excessive grazing and forest destruction, is one of the most important factors aggravating the desiccation of Africa.

The practice of burning has existed in Africa from before the days of Vasco da Gama and all legislative measures have failed to prevent it. Fire has an unfavourable effect on the moisture content of the country and from this point of view all grassburning may be considered detrimental; but after a few years of complete protection the amount of inflammable material would so increase that an appalling conflagration would sooner or later become inevitable. From the practical point of view controlled burning may be more effective than complete fire protection. We agree with the views of Mr. van Reenen, member of the Drought Commission, that the special circumstances of every case must guide the time and the degree of burning necessary to remove the surplus grass resulting from a summer rainfall. Burning tends to convert forest into grass land and in some countries is definitely used for this end. The protection of savannah forest or even its controlled burning will assist in the progression towards high forest. Where grass land is

the climax type, however, excessive burning can do nothing but harm and will result in a deteriorated and weedy pasture hastening the onset of erosion. Each type of veld, depending on climate, altitude, soil and type of vegetation, must therefore be dealt with on its merits and the degree of burning necessary to remove the surplus dry vegetable matter determined. This surplus vegetation must be removed in order to allow the new grass room to develop; mowing is generally impracticable and fire is the only alternative. All the existing evidence, however, points to the fact that this burning should be carried out with great caution, that it should only be done when absolutely necessary, and that it should not take place when weather conditions are such that the blackened surface of the ground will be left for months uncovered at the mercy of the desiccating powers of the sun and wind.

V. CONCLUSIONS.

We have endeavoured in our report to deal briefly with the subject of the influence of forests on climate, water conservation and erosion, both generally and with special reference to South Africa. We have pointed out the evils resulting from the destruction of the natural cover of the surface of the earth and the misfortunes which have arisen from such destruction. We have reviewed in a general way the much discussed question of veld burning. We have considered to the best of our ability in the short time at our disposal certain complaints received regarding the alleged decrease in local water supplies due to tree-planting and have recommended a scientific investigation of the whole subject. We consider that South Africa has a unique opportunity of carrying out such a scientific investigation which would be of inestimable advantage both to it and the world at large and which might allay certain fears which the public have expressed. Similar investigations should be conducted in other parts of the Empire.

For ourselves we are satisfied that the planting operations of the Forest Department can have had little or no effect on the general water supply of the country and that any effect they may have had has been beneficial rather than detrimental. We consider that the afforestation policy which has been pursued by the Government of the Union for many years past has been of the greatest benefit to the country by employing large quantities of labour and creating out of land otherwise unproductive, a valuable public asset which should later on support a prosperous local industry.

Lastly we appreciate the concern of many people for the preservation of the natural forest and flora of South Africa which should be the special care of the Forest Department. We are aware of many areas which have been reserved by the Forest Department for the preservation of the natural flora of the country, and we hope that this policy will be continued. There is ample room for

the indigenous forest, the natural flora and the plantation, and there is no reason why their interests should clash.

We hereby acknowledge all the help we have received in our labours both from the extensive published literature on the subject and from the gentlemen who have placed their views before us. We trust that our report may be of some assistance to the Government of the Union, at whose special request it has been prepared.

(Signed) C. G. TREVOR (*Chairman*), *Inspector General of Forests, India.*

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J. D. KEET, *Director of Forestry, South Africa.*

A. O'CONNOR, *Conservator of Forests, South Africa.*

R. S. TROUP, *Professor of Forestry, Oxford.*

R. W. THORNTON, *Colonial Civil Service.*

THE DEBATE.

FOREST INFLUENCES.

(a) SOIL EROSION.

(b) THE EFFECT OF AFFORESTATION ON WATER CONSERVATION WITH SPECIAL REFERENCE TO SOUTH AFRICA.

Mr. C. G. Trevor (India): In opening this debate, I would draw attention to the papers which have been submitted to this Conference. I hope you have them all before you, including the excellent contribution by Mr. Stockdale, the Agricultural Adviser to the Secretary of State for the Colonies. I have many times been likened to the prophet Jeremiah, who spent most of his time preaching evil things to a sinful world. Prophets are generally cordially detested, Governments view them with suspicion, and the crowd who are accustomed to listen to the honeyed words of politicians, telling them that they are the heirs of all the wisdom of the ages, resent having the follies of mankind and the iniquity of their ways pointed out to them. But generally speaking, it must be admitted that prophets have prophesied what has come true, however much they may have been disliked in their lifetime. No doubt Jeremiah can now turn round to his contemporaries in the place where he has gone, and say to them "I told you so"; if that is any consolation to him.

Now, gentlemen, we are called upon to discuss a very serious problem. Ever since our arrival in this country the importance of

erosion has been placed before us by all the public speakers to whom we have listened, and it is a good sign that in this country, at any rate, public notice is being taken of the evils of erosion, and of the importance of taking steps to do something to mitigate this evil, and the future dangers that will be entailed by a policy of neglect. Representing as I do one of the older countries of the world, I propose in the short time allowed to me to give you a picture of the result of disforestation in the ancient world. If you read history, you are bound to believe in the prosperity of these ancient kingdoms, and if you compare that ancient grandeur with their present decay, and their ancient wealth with the amount produced to-day, you can only be driven to one conclusion, and that is that the present decay of these countries is very largely based on the deterioration of the moisture that lies in the earth. Now, just imagine for a moment, what has happened to Persia for instance. Take the palace of the King of Kings, Darius, who at one time reigned practically over the whole eastern world. Can you imagine a man occupying his position, building his palace in the desert. But to-day, if you see the ruins of the palace of Darius in Susa, they stand in an uninhabited wilderness. Mesopotamia, which for generations produced all the revenues of Persia, by which that country was able to wage war against the Romans, has degenerated into a dreary waste and the hanging gardens of Babylon are a rubbish heap. No doubt the degradation of Babylon was partly due to the destruction of the irrigation works by the invasion of the Mongols, but already at that time, the irrigation system of Mesopotamia was in a state of decay on account of the destruction of the forests on the hills, and the bad régime of the Tigris and Euphrates which supplied the water for the finest irrigation system in the world, a vast system with which the Punjab at the present day cannot compare. The same history is repeated all over the world. In Greece, Anatolia and Spain, the destruction of the forests has seriously interfered with their climate, with their cultivation, with the moisture content of their soil, on which in the ultimate end, every nation and every kingdom depends. So much has this been the case in ancient history that it has been stated that disforestation, by the lowering of the moisture content of the soil, thus decreasing the water supplies of the country, has done more damage than any war, and has resulted in the destruction of the greatest empires. I do not intend to-day to do more than pass in survey the history of the ancient world.

My colleagues from Canada, from Australia and from Africa, will deal with the effect of disforestation in their own countries. I will confine myself to a few words about the effects of disforestation in India of which I have personal knowledge. Before the advent of the British in India, the area of forests was very considerable. Cultivation was precarious, and the keeping of livestock was a hand to mouth existence, because a man never knew how

long he would be able to keep his cows, owing to wars and famines. Consequently, the destruction of the forests did not proceed at any great speed. It is chiefly due to the introduction of peace in India, owing to the British occupation, that the population there has vastly increased, and that far greater demands have been made on the forests for cultivation, for firewood, for grazing, and for one thing and another, so that the destruction of the forest area, or rather the diminution in the area of the forests within the boundaries of India, has been going on at a very great rate, during the last 150 years. To give you an instance, when the Emperor Jehangir built the castle of Nurpur for his Queen, Nur Jahan, the Light of the World, he writes in his memoirs that the forest was so thick that a bird could hardly spread its wings. But if you go to that place to-day, you will see nothing but a denuded hill-country, with hardly more than a few tufts of grass and thorn bush, on which a few goats eke out a miserable existence. All that has happened in a period of not more than 300 years; in that time the dense forests which clothed the outer Himalayas have been reduced to a negligible amount. The Rajah of Kangra, himself the descendant of a very ancient line of kings, told me that they still point out where the machans or shooting butts were placed in the days of the Maharaja Sansar Chand. To-day those surroundings are as bare as this floor, there is hardly cover for a hare, let alone for a deer. It was in 1852, after the annexation of the Punjab, that we in our enlightened manner gave away all the outer hills to the villagers. Before our kind action in this respect, they were the hunting grounds of the nobility, but having conquered the country, we thought it expedient that all the waste land surrounding the villages should be handed over to these people for their mutual benefit. But what have they done? They have utterly destroyed the whole vegetation of the hills by burning, cutting and grazing. I would ask you to turn for a moment to the illustrations at the end of the paper for India*, which are more eloquent than any words of mine, of the appalling consequences of such action. You will see from those illustrations on Plate I, the entirely eroded surface of the outer Himalayas. You will see the remains of the vegetation, and if you turn to Plate II, you will see the cattle endeavouring to obtain some sustenance from the so-called grazing area. In the bottom picture you will see an assembly of the local villagers, protesting against the closure of their particular area of grazing, and if you examine the ground you will see that there is on it not a living thing, not a living leaf on the tree, which has been lopped to feed the last of the goats.

If you will turn to Plate III, you will see what you might imagine to be a watch-tower, but it is not. It is a well. When it was built it stood in cultivated land. The level of the land was naturally

where you see the top of the well, and what you see before you is the remains of the well standing in a dry and sandy river bed. All this is entirely due to the erosion and denudation which have taken place on the outer hills of the Himalayas, subsequently to the year I have mentioned, when these areas were kindly given away to the local inhabitants to do what they liked. Erosion may be summed up as ill-treatment of the surface of the soil. Whatever the cause may be, and there are several causes; first of all, in my opinion, comes the destruction of the forests by mankind, which has so often turned a garden into a desert.

Now, gentlemen, before I close, I would like to commend to you a few words from the preface to the "Arabian Nights":

"The lives of former generations are a lesson to posterity, that a man may review the remarkable events which have happened to others, and be admonished, and may consider the histories of people of preceding ages, and all that hath befallen them, and be restrained." If you and the Governments of the countries you represent will only realise this fact, and will consider the histories of people of preceding ages who have destroyed the virgin covering of the earth and what has in consequence befallen them, if you will take steps to see that in these enlightened days the same fate does not overtake us as has overtaken other nations, perhaps in a thousand years from now, the world will be in a better condition than it is to-day.

Mr. A. V. Galbraith (Victoria, Australia): In my paper on soil erosion and allied problems as affecting Australia, particularly those comparatively thickly populated parts influenced by the Murray River and its many tributaries, I have dealt with the two main forms of erosion, first of all water erosion and secondly aeolian erosion. Generally principles of cause and effect, and possible remedial measures for control of excessive erosion have been so frequently discussed that recapitulation here is unnecessary. Approximately 36 per cent. of the Australian Continent falls within the ten inch isohyet, therefore, water supply is one of our greatest problems. Whilst most of these more arid regions are of comparatively little economic value at the moment, bordering upon them are fertile lands requiring only a well-regulated water supply to carry prosperous settlements of people.

The Murray River drains an area of no less than 414,253 square miles affecting Southern Queensland, New South Wales, Victoria and South Australia or one-seventh of the entire mainland of Australia. If we add to that the coastal strip between the Murray and the sea, it would comprise one-fifth of the country, carrying 75 per cent. of the present population. Of the whole of the Murray River catchment area, only 158,500 square miles make any effective contribution to the volume of the river. The most reliable

thus diminishing fertility by baking the top soil, and promoting useless scrub. In other words, it upsets nature's balance to a very marked extent. Dealing with the question of wind erosion in the north-western portion of Victoria, we have what is known as the Mallee region, which consists of a raised estuarine plain, slightly undulating and representing about one-fifth of the area of Victoria with a rainfall of 10-15 inches. This region penetrates into South Australia and New South Wales. The total area of Victoria is 56 million acres, so you will gather that the total area of the Mallee is 11 million acres. The growth on that area mainly consists of stunted eucalypts but on the choice raised areas *Callitris* (Cypress pine) occurs, Victoria's only softwood. Wheat grows very well on these pine areas and the result has been that settlement has taken place to a marked extent in the last 35 years. In order to clear the land farmers have rolled out the Mallee and have destroyed the Cypress pine trees. A wise provision was made by the Lands Department in early legislation to reserve 3-5 chain breaks carrying tree growth between each area settled, also on the roads, but as recently as 10 years ago, Parliament decided that these forested strips between allotments could be taken over by adjoining settlers. Unfortunately this was largely availed of and the tree growth destroyed. The result has been that wholesale wind erosion has occurred and farmers are actually losing their seed wheat after sowing as well as suffering other disabilities.

On a small forest reserve in the centre of this settlement we are now working on our third tier of boundary fencing, the original fences having been covered by drifting sands; this has all happened within 30 years. In many parts, where we have endeavoured to plant trees on vulnerable sectors, we got very good growth perhaps for two years, and then a bad sandstorm comes along and absolutely covers the trees. A Joint Committee consisting of the Lands Department, the State Rivers and Water Supply Commission, and the Forest Commission, investigated this great problem and as a preliminary step to the reforestation of the bad sectors, these were the recommendations of the Conference: The area to be maintained under natural vegetation, from 3 per cent. on 640 acres, to a maximum of 6 per cent. on 1,280 acres, where the larger areas contained soils more liable to blow on account of the sandstorms. Secondly, the burning of stubble to be prohibited up to within 5 chains of the water channel or other work. I may mention that it costs the Government from £60,000 to £100,000 in bad years to keep the water channels clear of sand. Thirdly, the prevention of ploughing within three chains of a channel or other work, and fourthly, in letting out sub-divisions of Crown lands the provision of trees on roads should be carefully considered from the point of view of maximum timber protection from drifting sand. These are the recommendations which have been put forward by the Committee, in an endeavour to bring about vegetative growth on the bad sectors.

Finally, I would say they must be very arid indeed, before we would consider not placing tree-growth on the vulnerable land features of the State. We consider that the prevention of soil erosion is of paramount consideration.

Mr. J. D. Keel (Union of South Africa): In presenting my paper on the question of erosion and allied problems in South Africa, I need not remark on the importance of the subject before this Conference. This has already been done in far abler words than mine, spoken by Mr. Trevor and others who have already addressed you. I have not dealt with the cause and effect of erosion in South Africa at any great length. These matters have been so thoroughly investigated and are so well known and generally admitted, that a bare summary thereof will be sufficient for our purpose. Hence, I have rather sketched the policy of the State in regard to this question, as well as the steps that have been taken by the Government to secure the reclamation of eroded land and to prevent further soil erosion as well as to protect our major catchment areas.

Our legislation dealing with veld burning is reviewed. I have also touched on the question of drift sand reclamation in South Africa. In the case of both erosion induced by water, and erosion induced by wind, it is, as Mr. Trevor has very ably pointed out, mismanagement of the soil, of the veld, and of vegetation generally, often amounting even to abuse, that is the cause of all the trouble. I will not deal with those evils any further but I will rather proceed to say something about the other question before us, namely, the influence of the forests on climate, soil, and water conservation, and I will deal more particularly with the influence of forests on the water supply in South Africa. In order to understand the controversy that has raged on this question in South Africa, I may perhaps be permitted to offer this Conference a few general remarks on the climate of South Africa. The desiccation of South Africa—I use this word to denote the change for the worse in our climate, in other words the approach of the desert—has exercised the minds, both of scientists and laymen for a considerable time. Many have been the attempts to prove that the desert is really encroaching on us, and careful observers have pointed to desiccation in South Africa, illustrating their contentions by the hippo pools that are no longer in existence except in the form of dried up holes in the river beds, and to the disappearance of our forests which formerly formed the habitat for various wild animals such as buffalo and lions, and generally to the destruction of forests, and the approach of arid conditions in the areas which formerly held a far different type of vegetation.

But this has been measurable more in terms of retrogression of the flora, sinking of the water table and of the drying up of vleis springs and streams, with the consequent loss of stock and crops, and even the migration of the population than in terms of actual rainfall records. It was not until quite recently that proof has been

forthcoming that there has been a pronounced secular change, a marked downward trend in the rainfall in several parts of the country and the fact can no longer be denied that there has been a diminution in our rainfall during the past 40 or 50 years. The effects thereof have admittedly been aggravated by wrong methods of treatment of the surface of the soil. I, personally, do not ascribe this change in our rainfall to the destruction of our vegetation, because in parts where our forests have been destroyed this has been counter-balanced by the establishment of plantations over a very large part of the country. It seems to be questionable whether the mere deterioration of our grass land and scrub vegetation, can have affected our rainfall to such an extent. The factors governing our rainfall are probably far greater, and actually lie outside South Africa altogether. These are matters which we hope will right themselves in the course of time. Apart from secular changes, the South African climate is also subject to very marked and sudden fluctuations over shorter periods, and we have now at least come to realise that drought in South Africa may always be with us to a greater or lesser degree. This is the reason why steps are being taken in the form of anti-soil erosion measures to prevent further exsiccation (the drying out of the subsoil and the sinking of the water table) thus to ameliorate in one sure way the siccation of the country; the drying up of both soil and climate. I do not know how to express this so well in English as in Afrikaans, but we have a very descriptive term which applies to these conditions. It is the word "Verdroging". I can only translate it in English by saying it means "Drying out" of both the climate and the soil. Now, we foresters seek to prevent the siccation of the country by preserving the vegetation and by increasing the area of the forests, in the firm belief that there is no better agency by which to secure this object. We regard the mature forest as the best preserver of both climate and soil, and we also regard good forest soil as the best reservoir for water. In this we are guided by ages of experience in all parts of the world. It is not the maximum quantity of water, however, but the maximum beneficial yield of water that we are after. We cannot cater for the demands of those reservoir engineers, who realising that all plant growth, like all living matter, must use up water to live and grow, demand catchment areas paved with bare rock or land covered with malthoid. We have to bear in mind the lesson of those French engineers who once deforested their pine covered catchments to increase the run-off for their reservoirs and canals, but have at the cost of many millions of pounds been obliged to reforest these same areas, and with those same species of pine and other conifers that once grew there, when as the result of the deforestation their reservoirs became silted up and their canals stood dry. It is not quantity only, especially in the absence of filtered storage, which makes up water supply, but also the control and utility thereof, and it is not vegetation, but soil as the product of decomposition of vegetation, and of climate, that is the reservoir for rainfall. The retention an

protection in this country at great cost, of uneconomic grass land or scrub vegetation—I will not use the misnomer “*macchia*”—on water sheds on sites where forests can be grown profitably, is to my mind a questionable policy in the political economy of the nation. But our forests and plantations stand suspect. The significance of the mighty words of Humboldt that “by felling trees, which are adapted to the slopes and summits of mountains, men in every climate prepare for future ages at once two calamities: want of wood and scarcity of water” seems no longer to be realised or heeded. One can appreciate the apprehension of the layman, accustomed to the popular notion often overstated that forests increase rainfall and water supplies, when during periods of sub-normal rainfall, such as we have experienced for some years now, streams in both forests and plantations diminish in flow and dry up altogether. But the attitude of the scientist who urges these facts, without correlating them to our rainfall and the drying up of streams in adjoining non-forested land, is less understood. Some have maintained that the soil under plantations of pine is bare and subject to erosion, and that the plantations will sooner or later turn South Africa into a desert. I say that in this respect the forests stand suspect. It is known that trees dry up swamps. Indeed, trees are actually planted in order to drain swamps, for example in malaria areas. It is coming to be realised by some people that forests cannot be grown in deserts, even where country now desert was formerly covered with forests, the suspicion seems to be growing that it is not the destruction of forests which promoted the desert condition, but that it is, or may be, the forests themselves that dried up the water supply, and thus created conditions under which they can no longer live. It is also coming to be realised that they do not make rain, but that they follow rain. We have many species of alarmists in this country. We have had, and may still have what I may call the Kruger alarmist, as well as the Hoggeneheimer alarmist. We hope, however, that they are dead, but we still have other species. For instance, we have the climate alarmist, the donga alarmist, and the veld-burning alarmist. We foresters will find ourselves in better company with these latter without necessarily subscribing to the views and remedies suggested by extremists. But we have still another school of alarmists in this country, new to South Africa. That is what I may call the Forest alarmist—the forest alarmist who regards grass and veld generally, as more efficient agents in conserving the water supplies of this country. I hope as we go through South Africa, we will have sufficient opportunity to observe, and to find out for ourselves, that the suspicions or the alarms of these people are not justified. It is known further that the surficial run-off coefficient from denuded area is actually increased by a few per cent. and over a few years, at least until the soil becomes degraded and your springs dry up. It is also known that a thick mantle of lowly herbaceous vegetation can approximate in value

the effects of a forest in preventing run-off and erosion, and that the water table in forests may be lower at times than in areas which are non-forested, but it seems to be overlooked again that the moisture content of forest soils is more constant. It is our plantations, especially, that stand suspect. They are accused of being ecologically foreigners to our climate and South African foresters are accused of confusing natural forest conditions with exotic forest conditions, and that generally we have ignored the ecological outlook.

But, just as a farmer does not plant exotic apple in the low veld, or the exotic citrus on the high veld, so we foresters also do not plant exotic cluster pine on the coastland of Zululand, or the exotic *saligna* gum on the mountains of the Free State. I think the South African forester to-day can claim to teach the world something about the knack of matching species to growing sites, and I think our foresters need stand back to no one so far as working in conformity with ecological principles is concerned. Without this, we would soon have no forests at all. Mistakes have no doubt been made, but these do not condemn forestry as such. The forester lives with nature, studies nature, and follows nature's law, and if that is not ecology, I fail to see what ecology can be. I hope that after all ecology is not merely a case of adding new words to our vocabulary. There is one thing we have still to be convinced of, and that is that exotic trees acclimatized to their new home, are any more desiccators of the soil and climate, than they are in their native habitat. What we South African foresters do know is that exotics in South Africa, both the gum and the pine, and even the wattle often act as pioneers to our indigenous species, even to the moisture loving ones. This fact is very encouraging to us, and shows us more clearly than any measure of soil moisture and light intensities and temperatures and so on, that we are on perfectly right lines with our exotic plantations in South Africa. (Hear, hear).

We are confident of the future and of success. We know that we have not the whole of the South African people behind us, but we feel perfectly sure that we shall gain their support.

Mr. J. R. Ainslie (Nigeria): It seems to me that in this Conference I am fated to deliver supplementary reports and typescript, as well as printed reports prepared by the Government. In this case the supplementary typescript report was asked for after the published report was prepared, and deals mainly with historical and other records of desiccation in West Central Africa; the printed report deals with Nigeria alone. Now, Nigeria is not as a great many people imagine simply a huge swamp formed by the delta of the River Niger; there is a huge delta, it is true, but behind the delta lies a vast extent of country, nearly 300,000 square miles of higher land mainly covered with Savannah forests; these Savannahs stretch right across the continent of Africa from east to west and north and

far back into the country behind. That system brought about very intensive settlement along the St. Lawrence River itself. I am now speaking of the actual bottom lands, the areas immediately along the St. Lawrence River. A little back from the river, the land rises and there are heavy stands of mixed hardwoods with an admixture of conifers. In various parts of the province there are numerous areas, some large and some small, where sand dunes have been formed, as result of clearing land which ought to have been retained under forest cover, for two reasons, first that they were not really susceptible of successful agriculture, and secondly, in order to protect adjoining good agricultural lands from soil drifting, the lighter lands should have been left under timber. Several members of this Conference, on their visit to Canada in 1923, themselves saw the sandy areas to which I have referred.

In Quebec, although we have not hydrometric data extending over a sufficient period of years to enable us to draw conclusions, it is nevertheless perfectly obvious to anyone who has travelled in the province that not only has the clearing of lands which should not have been cleared resulted in the reduction or disturbance of the stream flow, but timber operations in the hinterland have also had an effect in this direction. The country lying behind was exceptionally well wooded; it is there that extensive operations for the production of timber for lumber and pulp and paper manufacture have taken place for a great many years, and where also unfortunately fires have done great damage. As I say, it is perfectly obvious to anybody who has had the opportunity of looking at these lands, 25 or 30 years ago, and to-day, that there has been an appreciable disturbance to stream flow.

Now, taking the next province, Ontario, I shall refer briefly to three specific instances. In the first place, there is the area known as the Trent Water Shed, which was settled upwards of one hundred years ago. The Trent River drains into Lake Ontario about the middle of its northern shore. This also was a territory of very dry and more or less light sandy soils. It was settled as I say about 100 years ago, and for many years farming operations there were carried out with an almost constant decline in the success of the agricultural operations. Arising in that region, we have what is known as the Trent Canal, the water for which was to have been drawn from the Trent River itself and from various other rivers which are found in the district. I need only say that the Trent Canal has been largely an unsuccessful venture. I do not attribute that entirely to the denudation of the forests in the district surrounding it, but certainly that condition has contributed to it.

The second instance to which I would refer is further west, namely, in the valley of the Grand River, a river that drains a substantial part of what we regard as older Ontario—that is the more

settled part of the province. This river drains into the second of the great lakes, Lake Erie. I have never actually lived on the Grand River or on any of its tributaries, but I do remember as a boy being taken over parts of Middle Ontario by my father and others, and visiting small towns and villages on the various tributaries of the Grand River. Between then and now, is a period of some 39 or 40 years, and I assure the Conference that there has been a tremendous change in the conditions all through that country. Substantial towns and cities that were built up on the various parts of that river system, have been subjected, particularly within the last ten or fifteen years, not annually, but very frequently—perhaps once in three years or so—to very serious floods; and these have done great damage to these towns and cities, and also by reason of the erosion to the surrounding agricultural country. I need not describe in detail another river which drains the western part of Ontario, the Thames River system, where conditions are similar to those I have described.

Now, just for a moment, combining the conditions existing in the two provinces to which I have referred, Quebec and Ontario, we have to the south of both of them the great St. Lawrence River. For the past ten or twelve years the question of the depth of water in the river has been giving serious concern. The gradual lowering of the water has become what I might call one of the more serious problems on the American Continent, affecting both Canada and the United States of America. I feel sure that many of you have read proposals that have been made for the development of the St. Lawrence waterway. Recently it has become perfectly evident that there has been a gradual but perceptible lowering of the St. Lawrence River. Various bodies have met together and discussed the question and as recently as six or seven months ago we were called upon to give some consideration to it, and to advise, if we could, as to what effect forest denudation in the Ontario and Quebec Provinces and possibly in the adjoining territory of the United States to the south could have had on this question. We have therefore set to work in a preliminary way to deal with this problem, and we are now gathering together all the available data on the subject. It appears to be quite certain that even with the limited data available we are going to be able to draw some fairly definite conclusions—not conclusions, perhaps, which will have the effect of convincing extremist engineers, but which will, I think, be quite in accord with the views of other engineers who, while doing the utmost possible for their own profession, still see the need of natural methods of control; because, after all, over a long course of time, there is no doubt that it has been man who has disturbed the natural conditions of the country to which I refer. Before leaving the question of the St. Lawrence waterway, may I say that along this large river, which constitutes as far as the great lakes are concerned the international boundary, we have the older and more settled part of Ontario, and

the settled part of Quebec, both on the north and south shores. And we also have the American States of Minnesota, Wisconsin, Michigan, Ohio and New York, all of which are very densely settled. We have the pineries of Northern Michigan and Wisconsin, or rather we had them at one time, because those pine forests are practically now of the past. Large portions of those States were seriously denuded, even more so than Quebec and Ontario. These conditions have contributed to the lowering of the St. Lawrence Waterway.

Now in regard to Western Canada, I shall be rather brief. In Manitoba, we have an area not far north of the international boundary, toward the western side of the Province where there are hills known as the Spruce Woods. This area was until the late eighties quite densely wooded. As a result of the indiscriminate cutting and timber-stealing that went on, the once extensive spruce forests were seriously denuded. This is not wholly the cause of the trouble, but right within the area itself there has been a very decided reduction in the water table, and also in the surrounding country.

In regard to the Province of Alberta, I can speak with more familiarity, because in it for many years I carried on my field work, and later had charge of the district. In Alberta we have the eastern slope of the Rocky Mountains, an area which is the fountainhead of the river system of the western plains draining the southerly half or two-thirds of the Province. I think my friend Mr. Caverhill will recall that in 1910 he and I rode up the Elbow River not very far from Calgary. We then turned up a branch known as Canyon Creek. For some three or four miles we rode up the rough boulder-strewn bed of the creek. There were no signs of water, except here and there a few little pools. A few miles up the river we came to the stream which was losing itself among the boulders. Now the previous year there had been a tremendous forest fire in that district, and a few years previously there had been another bad fire. In the year 1910, of which I am speaking, after we were there—I had better say a month afterwards lest we should be suspected of causing the fire—the region was again ravaged by fire. For several years the conditions to which I have referred were present, accompanied by a lack of water in the lower reaches of the creek. This continued for some time, notwithstanding the fact that the years 1911, 1912 and 1913, were years of abnormal precipitation. However, as so often happens in our Canadian Rockies, we get a very good reproduction of pine with a certain admixture of spruce. In more recent years, I have on two occasions ridden up the Valley of the Elbow River and I have seen the Canyon Creek discharging water at its visible mouth into the Elbow River. I do not say that this is entirely due to the influence of new forest cover, but I do say, with all the force I can use, that I am quite convinced that

it was primarily the result of the re-establishment by nature of the forest conditions, not as they were previously, but rapidly working towards it. In the United States of America there have been similar experiences. I am not going to make any prolonged reference to that country this afternoon, because obviously we are discussing forest questions within the Empire. I may, however, make the general remark that the conditions which I have described as applying in the Provinces of Canada obtain also in various parts of the United States.

Before taking my seat, however, I should like to make a few general remarks. I have not been all over the world by any means. Perhaps I have not travelled to anything like the same extent as some others here. But one thing that has impressed itself upon my mind is this: Whenever I go to a country in an entirely different part of the world, at once I hear that the forest problems there are utterly different to those which we encounter in Canada. That was the case in Australia for instance. It was the case in the West Indies. It is the case in the Union of South Africa. It was also the case in the Hawaiian Islands of the Pacific, and so on. They say that the problems which they have to face are so utterly different to ours. Now, taking my own country, as between the forest regions of northern Saskatchewan, Alberta or Manitoba and, say, the forests of New Brunswick, lumbermen in Saskatchewan, for instance, will tell you that their Province is so utterly different to New Brunswick. It is quite true, of course, that there are points of difference, but I must say this, that when we consider this problem in its elements and when we get down to the basic principles of the thing, I have been struck rather with the points of similarity in the basic problems than I have by the points of difference. Mr. Trevor said yesterday that we cannot in discussing this question of forest influences leave out of consideration everything relating to climate, water conservation and so on. We must recognise that a good many of these problems have engineering phases, and that some of them are in fact almost purely engineering problems, but as I said in my earlier remarks, there are engineers who do not take the utterly extreme view. There are engineers who fully recognise that forests can have a very beneficial effect on these factors that we are discussing. On the other hand, we as foresters must recognise in our consideration of this problem that due importance must be given to the engineering aspects.

The other day we stood on the margin of Mr. Holley's land near Martizburg. We saw on one side a certain condition of things, and on the other side an altogether different state of affairs. There was no comparison between the results of what had been done on the one side and on the other. These results were evident to us all. We saw what had been done in the one case, and what ought to have been done in the other. There was no use in saying that if certain things had been done on the other side of the valley the owner would have

let us forget the theoretical concepts with which we are nurtured in the various forest schools of the Empire. And then again when we look into some of the soil conditions in relation to acacia and gums more especially, we find somewhat disturbing conditions in terms of water retaining capacity, aeration, of hydrogen-ion concentration or acidity. I do not say invariably, but in many cases the conditions are far less satisfactory than those obtaining outside such stands under natural vegetation of whatever kind it may be. Especially would I like to point out that much of the litter that falls from these exotics is not incorporated into the soil, but lies on the surface for a long period, ultimately very largely disappearing in gaseous form, not being incorporated into the humus in the soil. It has been suggested that by management of the stands, we shall be able to ameliorate these conditions. I would grant you that up to a point a change in management might make worse better, but I cannot grant that it will make bad very good or as good as the conditions under indigenous vegetation. I would ask you to cast your minds back to what you saw at Cramond and Broadmoor as regards the conditions of wattles managed on the new system in contrast to those managed on the old—where under a higher light intensity under the new method, there was upon the ground little or no weed growth, whereas under the old method there was definitely grass growth and in some cases herbaceous growth as well. These conditions are due to a difference in the water content of the soil, and we know from experiments carried out—not with this particular species, but with other plants, notably grasses—these differences may largely be the cause of a greater use of water, the more vigorously growing trees being able to reduce the water content of the soil to a greater extent than those in more crowded stands. Again, it is asserted in a memorandum by our local Forest Department that foresters would claim that the pine plantation is the most powerful agent in the prevention of erosion. But I would like South African foresters to look at their indigenous scrubs, such as the fynbos and the *macchia* or *maquis* (which by the way is not a misnomer), and the conditions under properly managed grass veld—I can assure you that the indigenous vegetation is either as good as or better than these pine plantations. I personally have noted an amount of run-off, especially after heavy downpours, in pines, in the Knysna area, where under *Pinus pinaster* on a slope, after the initial fall there has been a considerable amount of run-off which has found its way to the indigenous forest below. It has been said also that the indigenous species, which require very congenial conditions before they will grow, even find their way into the exotic plantations. I know this, but I also know that this occurs only under certain sets of conditions. We must be scientific and present the whole picture, and not a partial one. It occurs where there is a large rainfall, where the plantations are in close proximity to forests, and where they have been developed upon old forest ground at no great distance

from forests. But it does not occur elsewhere. It remains to be seen whether those plants that have come in, will be able to go through all the stages of development, more especially when periods of local drought intervene, because the water requirements of many of our indigenous species, I know from my own investigations, are extremely high. The wilting point is soon reached, and it is reached before the wilting point is reached by the exotics. Then again, in regard to the incoming of indigenous species elsewhere, it has been claimed that indigenous plants, so called succulent plants, come in in areas like the Free State and Transvaal. But if we look into the matter, we find that what is happening is this—that pioneer grasses like *Aristida*, and probably pioneer herbs are under these stands of gums and wattles, whereas within thirty or forty feet of the margin of the stand there is a much higher type of vegetation—very much more demanding in its water requirements. It is all a matter of comparison. It is again said on page 5 of the Memorandum by the local Forest Department to which I have referred, that the best way to re-establish destroyed forests is to introduce exotics, especially pines. Well, I have worked in the indigenous forests of Knysna, George and the Humansdorp District. I spent five or six years there, and I also know something about forests in the Eastern Cape—I served there for several years. Mr. Chairman and Gentlemen, as a silviculturist interested in indigenous forests, I put it to you that it is very definitely a mark of defeat if we, charged with the silviculture of our native forests, have to call in exotics to help us in that management, when we can find other methods which will give us the results required. I maintain that there are other ways of doing it. The natural way to extend our indigenous forests would not be to use these exotics, but would be to encourage the shrub and small tree stages of the natural succession—the *Virgilia capensis* in the South-Western Districts—the *Leucosidea* in Natal and other species in other parts, where by the natural process of succession, these plants would act as nurses, and with suitable thinnings should be utilised for the raising of young seedlings for full development to forest conditions. It is claimed that there is a very small area under exotics in the Union in comparison with the general surface of the country, and that is admitted, but surely that does not in any way argue that we should not give most careful attention to the reports, and to the conditions that can be demonstrated on the ground, regarding the reduction in stream flow and the drying up of springs where small wood lots in this way have been responsible for that reduction. It does not remove the onus one iota; it should all the more make us look into the matter lest we find where we have a large area of exotics we have done harm instead of good. There are local facts that are very definite and can be demonstrated and that is why I am expressing the point of view I hold.

And, now, finally, regarding policy; it is not much use saying that this is happening unless we can suggest some way of approach-

ing the problem, and I put before you several points that I think are well worth consideration in this connection. First of all, we do need to know a great deal more than we do at the moment. The planting up of sites must be considered in terms of water supply: only those could contest such a policy who have sufficient data at their disposal. I ask you again to forget traditional concepts. Here we need long range research—we want to select certain catchment areas which will have a number of streams. We must investigate the régime and life-history, as it were, of these streams over a sufficient period. We must do this quantitatively, and we must work most critically and with a sufficient number of these, and treat them in different ways. We must consider their sources, and treat these sources in different ways; we may plant the first source and manage it differently to the management of the other sources; we may protect the second source from fire, and let our native vegetation develop; we may burn the grass on still another source, and so on, until we have a sufficient number of replications, with duplication or triplication in different parts of the Union—in other words, a series of experiments that will enable us to separate the relevant from the irrelevant. I do claim that we have not yet done that and it is up to us to do it. It will take 20 or 30 years, but it is worth doing. We must do it, just as the same work is being done in America, and with a sufficiently critical basis. Then again there must be habitat development studies for various regions in relation to different exotics, under different systems of management; this requires careful study. We must first of all investigate the area, chemically, physically and biologically. We must then treat it silviculturally—plant it and control it—and we will then in course of time be able to collect data with reference to development and the changes that occur in the soil, because the soil is as dynamic as the vegetation. Then again, succession changes require careful study in connection with the reafforestation of areas, more especially where scrub and forest growth has been before. I think that here a great saving in run-off and undue use of water by trees can be brought about, if we bring our plants in at the correct stage in the succession. There is a very important point that I should mention in conclusion. Before planting certain areas that may be important locally or in relation to the question of water supply, let us wait until we have sufficient data to satisfy ourselves that we are correct. It has been said this morning that problems are much the same in general principle in different parts of the world. But I should like to put the opposite view, that we are finding more and more that the problem on one side of the hill slope is not necessarily the problem on the other side.

Mr. R. W. Thornton (Basutoland, Bechuanaland and Swaziland): I am attending this Conference as an Agriculturist, not as a Forestry Officer, but there are one or two points which I should like to mention from the agricultural side of this great question we are

dealing with. Unfortunately every country that is inhabited can hardly be maintained in the condition in which it was found prior to its invasion by man—man who should be the protector but who is often the destroyer.

In our agricultural practice as compared with the forestry practice, I would like to mention the cultivation and production of maize. Maize is a crop which is produced over a very large area of country, and from investigations made, we find that where it is grown and where similar crops are grown, the loss that takes place in regard to surface soil, and the colossal loss of water that occurs could hardly be equalled in connection with any type of forestry practice. I mention this as it has a bearing on the whole question of soil and water conservation. I would now like to deal with this subject from a slightly different point of view to that dealt with so far. In one of Kipling's famous Indian stories, he mentions a village surrounded by forest—where the forest was dominant—the people were removed, and the jungle took possession. This case is comparable with what I saw in the Southern Sahara a good many years ago, where a once flourishing oasis had existed. The palms had been cut down and the desert had rolled in and taken possession. I therefore feel that whatever the opinion may be with regard to our rainfall decreasing, the desert is rolling in and taking a great portion of this country from us, due to the destruction of tree growth. The position is one which necessitates very careful investigation. We know of three (what may be called) low climax periods or rainfall periods in the years 1802-13, 1862-63, and 1932-33. In these periods it looked as though the desert had taken possession. The dust drove over from the west and covered the Free State and in many parts there was a layer half an inch thick. Trees would have prevented this wind erosion as they do erosion by water. Trees are the best agents for slowing down water flow, and the slowing down of wind velocity near the surface of the earth. If we can slow down our water flow we naturally check erosion, and if we can slow down the wind velocity near the surface of the earth, we not only check erosion but we reduce evaporation. I do not desire to go into detail in connection with any dispute that may arise between the advocates of afforestation and its opponents, or the question whether afforestation may or may not be desirable in certain sections of the country. But I wish to stress the fact that burning on a gigantic scale takes place throughout the grass veld and savannah areas of this continent. There is no control of the burning which has denuded the country of vegetation, thereby breaking down not only the ordinary grass, but destroying and curtailing the whole of our tree growth. The destruction of the tree growth must at least have this very vital effect, that the principal slowing down agent to the movement of wind over the surface of the earth is removed, and therefore we must have wind erosion and high evaporation from the earth's surface. This is not only a South African question: it is an international African question,

and indeed affects the whole continent. Africa is in a peculiar position in that the continent is inhabited by some 143 million native people—who have not reached a very high state of civilisation—and some three million Europeans dotted about the country from the Cape Coast to the Mediterranean. With this uncontrolled burning that takes place not only in the native areas but also in some European areas we are definitely concerned; it destroys the natural vegetation and particularly the forest vegetation, or the natural bush which is the principal agent in the slowing down of the flow from our heavy storm rainfall and the velocity of the wind. In 1906 we carried out certain evaporation tests, one set near the coast, in a section of the country where the rainfall was only ten inches, but where humidity was highest, the second in an area of a 25-inch rainfall up country, where the humidity was very low, and we found that the actual evaporation was greater in the 25-inch rainfall area than in the 10-inch area. Forests and forest growth may not perceptibly affect the rainfall of a country, but they must, I think, have some effect on the humidity of the atmosphere, and they certainly assist against the terrible drying out process that takes place due to the high winds. Finally, I would urge that this Conference, before it breaks up, should strongly recommend that investigations covering this whole question should be carried out, not only in this country, but wherever a similar set of conditions exists; I think that a very wide range of experiments and investigations should be carried out over a long term of years. Speaking as an agriculturist, I would not like to see that during the period occupied by these investigations any slowing down should take place in the work of preserving the natural herbage of this country, and particularly its tree growth, and no slowing down with regard to replacing that growth where it has been removed due to the destructive agencies mentioned.

Dr. Reynecke (Union of South Africa): I must say that this is a great surprise to me and not a very pleasant one in that I have not prepared myself to speak on this matter. I have been much interested and impressed in the question brought up by Mr. Keet, and which was so thoroughly gone into by Dr. Phillips. I think that possibly Mr. Keet has in mind the mass effect of afforestation, and not so much the local effect that it may have on a particular area or a particular spot. I hope the foresters will discuss this matter in a broad sense. Speaking as a man who has grown up in this country I have been very proud of one of our first Governor's actions, or decrees, and that was that any man who chopped off a tree should plant two in its place. Now speaking as one who has only recently entered into a new Department of State—the Native Affairs Department—I must say I agree with the previous speaker as regards my superficial observation, and that is that while the trees may or may not by transpiration take more water from the soil they certainly

have an enormously beneficial effect in reduction of the high evaporation such as we have in this country. The effect is shown directly by the results on vegetation, which grows under the natural scrub timber that we have in South Africa. The bushveld region which is largely occupied by our native peoples and only very incidentally by the white farmer, is subject to enormous destruction to-day through the felling of native timber. In those cases we find desert conditions approaching more rapidly than where the native timber has been maintained. We have some of our best grasses growing under these trees. In fact from the agricultural and pastoral point of view we find that our best species grow under these trees. The trees themselves are no doubt deeper rooted than the exotics which we have introduced on a large scale, and which have a surface root system. The others have a deep root system. But whether we take the exotics or the other kinds, there is no doubt that the accumulation of moisture, or rather the humus which holds the moisture in the surface soil, is greater under the trees than in the open veld, and we find in the case of exotics anyway that we have some of our best grasses growing there. Viewed from the purely pastoral or agricultural point of view, I must say that my own observations lead me to this conclusion, that afforestation in areas that have been deforested is essential. In native areas especially it is imperative that we not only conserve the natural timber but that we replace the timber where it has been removed. In order to check the enormous surface evaporation, and to check the surface erosion which is caused by water and wind, this policy is essential. I was struck recently on some of my visits to the sand veld in the eastern Transvaal at the enormous deterioration which has been caused through the chopping and felling of timber by natives. In the sand country it was observed that where these native trees have been felled the ground begins to move, first of all through man stirring it, and after that the winds blow and move the sand and throw it upon the land in the form of dunes. So that from that point of view especially—that is from the point of view of erosion by wind as well as water, I do feel that not only should the conservation of our natural timber receive careful attention, but where necessary we should replace this natural timber either by native timber or exotic timber. It is a question which should receive very serious attention. I would like to say that I am all the more concerned about the re-establishment of our native timber. I realise that the process is a very lengthy one, and no doubt Mr. Keet and his co-workers feel that the process is too slow, and is of doubtful value. But it seems to me that a different aspect has been brought out by Dr. Phillips in regard to the habit and growth and rooting system of most of the exotics in this country as compared with our own indigenous trees. The question of allowing native timber to re-establish itself is also a very difficult one and it seems to me that in many cases in certain areas that I have to do with the process is going to be rather slow, if we leave it to

nature alone. My question, therefore, is, cannot we do something to help nature in re-establishing these forests by actual planting, and in other ways inducing the native timber to become re-established.

Mr. Roberts (Union of South Africa): As Dr. Reynecke has mentioned, this debate has come at rather short notice, and therefore I am not very well prepared. But I speak as an engineer, who is interested in anti-soil erosion work. I have really only one point that I wish to bring out, and that is this, that from my own observation forestry as generally practised consists of trees planted fairly close together in regular formation, and apart from the pines that make a fairly extensive litter underneath, the gums and similar trees cause the ground beneath them to become totally bare and dried out to a very great extent. Now, one of the earliest speakers this morning mentioned that in Nigeria I think it was, in the high rainfall area of 360 inches, peculiarly enough the erosion was less due to water than in the other area where the rainfall was only ten inches. Well now, that is exactly our own experience, and I put it down to this fact, that if soil is kept continuously moist to a certain degree, the root systems of the smaller plants never entirely die out, and when storms come, the soil is bound together by this tiny but all-pervading root system. Our trouble here is where you get a semi-arid area, and where everything grows well including grass and small shrubs until you get a drought, and then these small roots die, after which you are at the mercy of the first storm that simply rips out the whole area. That is the trouble. So that I feel very strongly, partly from the point of view of anti-erosion work that our indigenous bush in South Africa has enormous advantages. In the first place, speaking subject to correction, I believe that our indigenous trees do not draw on the water in the soil as heavily as some of the exotic species. Secondly, the growth is such that they do not stand alone. As trees, they are accompanied by all forms of shrubs, grass and other vegetation, which blend together and form more or less a complete protective mat, and therefore I wish to suggest that every possible attention be given to the possibility of bringing back our indigenous bush with its accompanying vegetation wherever possible.

The Chairman: I should like to know whether we have with us to-day any gentleman who will not be accompanying the Conference in its further stages, and who would like to speak on this occasion.

Mr. Carlson (Union of South Africa): I must apologise first of all, because I am in a rather bad condition of health just at the moment, and I find it very difficult to speak at all, owing to the fact that I am suffering from an abscess on my tongue. There is only one point that has been brought forward that made me rise, and that is in regard to the remarks made by Dr. Phillips. He made a very strong point in regard to the difference in the conservation of moisture in the natural forest soil as against the soil in which exotics are planted. I would just suggest this, that he has perhaps overlooked one fact in

making such a big distinction between exotics on the one hand and indigenous trees on the other hand. Now the point that comes to my mind is this, that the indigenous forests as we know, are composed of a large variety of species with different kinds of foliage, which when it decays makes very excellent mixture of humus, and one which retains the water like a sponge. Certainly we notice that the same thing does not happen at all events to the same extent in pure pine or pure gum forests. I have thought over this matter a good deal during my half century's experience in this country, and I have always felt that what we want is to find a means of mixing our species to as great an extent as possible, not only from the point of view of the conservation of moisture, but also from the point of view of producing better qualities of timber. You all know that there are many species of trees in the world, which produce much better timber, by mixing different species than they do when they are grown pure, and therefore I feel sure that it is not beyond our ability to find suitable species for mixing in many situations in this country.

The Chairman : I am sure you will all wish me to thank Mr. Carlson for his remarks. He is one of the oldest technical officers in the Union. (Hear, hear.)

Mr. Hunt Holley (Union of South Africa) : In my remarks to you to-day, speaking as a layman, I shall endeavour to approach this subject from as practical a point of view as I possibly can. Comparisons between exotics and our indigenous forests have been made. I am satisfied in my own mind that if it were possible to speed up the growth of our indigenous trees and plant them in pure stands in a similar manner to that by which we have treated our exotics, we would get precisely the same results. Now I do not know if it would be possible to do this, but it would certainly be a very interesting way of approaching the subject. References were also made to wattles—probably the greatest criminal ever introduced into South Africa in the opinion of some, if the matter is looked at from one particular point of view. Gentlemen, I am exceedingly sorry that when I had the honour of demonstrating to you what could be done with the wattle, ample opportunity of studying this particular tree was not given to me. There were many examples that I could have shown you very much better than the examples that I was able to bring to your notice. But unfortunately, time did not permit of this. The bareness of the conditions under our trees grown by new methods was also mentioned by Dr. Phillips, but, gentlemen, whether the soil is bare or whether it is not I undertake to say that no member of this Conference was able to find any trace of run-off. Now, Mr. Chairman, surely those of us who are growing exotics in this country have just as much right to the use of the water as anybody else. At least I contend that we have as much right to the use of the moisture of this country, provided we use it as it should be used. At any rate we have as much right to the use of the moisture as for example the people in the city of Pretoria. I understand that this

city of Pretoria uses approximately 11 million gallons of water a day. That of course definitely means that the people below Pretoria have so much less water. But surely that water is being very well used. I have made use of a very extreme case, probably, but I wish to emphasise the point I am making that we both have the same right to the use of the moisture in the soil, provided we make a right use of it.

Professor Sutton (University of the Witwatersrand): The request has been made that some of us who have special knowledge of South African conditions but who are probably not directly associated with Forestry, should say a few words on this subject. Now, in saying what I am about to say, I want to approach the matter from the point of view of a Civil Engineer who has specialised in Irrigation. That is to say, to a certain extent I start really at the end of the story, namely, as an engineer who takes the water as it arrives in the street, and he is naturally concerned both with its quantity and quality. I think there is no engineer who would disagree in the slightest in regard to the point that everything possible should be done to bind the soil together, as Mr. Roberts has explained. So that we have the water running into our rivers and flowing along and not carrying large portions of the countryside with it, thereby silting up our reservoirs and channels. So that we now come to the other side of the question, namely, that of quantity and mode of distribution. Let us take the position and examine it from the point of view of the engineer. As regards South Africa, we find that the only satisfactory position known to-day is to make an analysis of what total water has fallen on the catchment area, as the results of the records obtained from rain gauges, and what water has passed over some particular gauging point. The position in South Africa is a most distressing one in spite of all the grandiose talk about our huge water resources which do not actually exist. If we average the position, probably we shall find that some streams do not give more than half to three-quarters of the run-off, as we put it in percentage form. Probably if you take the whole country only about six per cent. of our rainfall finally appears in the rivers. That is to say, we have to face this fact, that when rain falls on the surface of the earth, it is disposed of in three different ways. Some of it runs immediately off the surface of the soil; some goes into the soil; and the balance we can only assume is lost by evaporation. Therefore, we must take it some 94 per cent. of the water that falls on the land never re-occurs. That is to say, it does not appear in any direct process. Now the engineer, naturally working between the two extremes of the initial rainfall and the final result of the run-off of water, as it is found in streams, is interested in all the intermediate stages to which this water must be subjected, and he comes to the conclusion that it is affected by the physical topography of the country, the geological formation, and the porosity of the rocks as well as the natural surface cover. And it is at this stage that the interests of the irrigation engineer and the forester

are almost identical. The problem it seems to me is nevertheless one for the forester, and not directly for the engineer, and we simply have to face this fact. One speaker, Mr. Keet I think it was, referred to the sort of super idealistic notion of what we may term the 100 per cent. run-off catchment area. I admit that if you make it very steep, and absolutely impermeable, then a catchment of absolutely 100 per cent. would be recorded. In fact, that has been done on a small scale, in places like Gibraltar and Southern Australia, but it is essentially a very small problem of a very small water supply, and the engineer has no interest really in that form of collecting water. When it comes to large scale operations, particularly in a country like South Africa, where you have extremes of dry winter and heavy summer rainfall, the serious problem which confronts the engineer is to decide what he is going to do with this water assuming he can get it. You may collect the water in the reservoir, or by means of dams in the rivers, but in any case that water is subject to extremely high evaporation, and therefore to a large extent, after conserving it he has to lose it once more, so he comes to the conclusion that the forester is the chief person who can help him with this problem. Of course we know that there are some trees which break up the soil and provide some opportunity for water finding access to underground strata, and we pay a small penalty in the case of transpiration which goes on in connection with these trees. (Hear, hear.) Now, naturally it is not for the engineer to discuss whether one type of tree or another would best suit the conditions of South Africa, but it seems logical that if trees are to be planted simply in order to increase the water resources, they should be those which break up the underground sub-soil to the greatest extent, and which at the same time use up water to the smallest extent. The forester, therefore, makes one of the biggest contributions to the water supply of the country to the extent to which he slows down the natural run-off, and reduces those other conditions which cause the loss of moisture. To that extent his services are of the greatest economic value. So we find that the forester is really engaged in creating an underground reservoir throughout the country which feed the streams not only directly but all the wells and windmills which rely upon it.

In conclusion, Mr. Chairman, I should like to make this remark, that we have very little true information in this country regarding the relations between rainfall and run-off under specific conditions. We know for example that on an average any half inch rainfall in South Africa is of no use because it goes off straight away in evaporation, and if we are dealing with the question of run-off and rainfall relations we consider that if we are to do the job properly, we must eliminate all rainfalls of less than about half an inch as being of no effective value whatever. Therefore, it follows that the effective rainfall in most places in South Africa is extremely small. I think myself that the only way in which we can get any true data on this subject is for us to gauge small catchments, and for the Forestry

Department and the Hydrographic Survey Department to combine together in order to get hold of catchments or the same catchment which can be sub-divided, assuming it is a river. You must have the same rainfall conditions and topography applying to one portion or tributary, and you must plant one type of tree, say the exotic species in that portion, and you must plant the other with indigenous trees; then after a certain period of time you will have comparable data. I would like to see full co-operation established in this work between the Forestry Department and those who are interested in the water supply directly, which I think must be to the benefit of the country as a whole.

Mr. T. M. Mackenzie (Union of South Africa): Speaking as a wattle grower, I think Mr. Hunt Holley has covered the ground. I think that under the newer methods we have adopted, we are now conserving as much moisture as we can on our farms. Our experience is now that whereas formerly there was a good deal of run-off after a storm, there is now very little. In fact one may say there is no run-off on our farms at all. Our springs are stronger during the winter than they were previously, and we feel convinced that we are at least retaining the water on our farms instead of allowing it to run to waste as was formerly the case, and furthermore our present methods enable us to retain the earth which was formerly washed away by these heavy downpours. I might mention that I was quite a young boy when my people first came to South Africa, and they built the house under the hill because there was a stream close by, and I remember in my young days there was a duck pond in front of the house. Well, that stream, through there being no afforestation at all, absolutely dried up. That was due to not planting trees, but whether there was burning as well, I do not know. What I do know is that by the time I was 21 we had to find our water elsewhere. Things are very much better today in that respect. And I want to add this, that that was before we planted any of these horrible wattles that we sometimes hear so much about. Before the trees were planted, the stream dried up. We tried windmills, and eventually I piped water from a considerable distance to my house, which I have built on the hill. As I say, conditions are much improved. I mention this case because we hear from time to time the cry that South Africa is drying up—or that portion anyhow. As far as burning is concerned, I am looking forward to the day when the only fire that will be allowed on my estate will be the one that cooks the meals. We will have no burning at all—no bush fires or any thing else of that kind. I agree that the devastation of the veld in the spring when our first rains come must be largely due to that cause, and through that we lose most of the water. So I look forward to the time when there will be no fires at all, neither grass nor bush fires. With regard to forest areas, I think some legislation might be brought forward in that respect, that in such areas no fires should be allowed at all. I think that would be a great help in preventing

the huge fires which occasionally devastate these forest areas and that in my opinion occur mostly from carelessness.

Mr. G. A. Wilmot (Union of South Africa) : I did not intend to contribute anything to this debate, but I consider it my duty to say something, because I have practised afforestation and am still practising it. In fact I have been engaged in this work for 33 years. At the present time I am on the research committee for the wattle growers. I have listened with considerable attention to the remarks which have been made, and in particular to what Dr. Phillips has said, and were it not for the fact that I know that the Forest Officers of this country are most thoroughly conversant with the points he brought forward I would urge them to give very close consideration to them. But as I say I know they are doing so. I know they are fully alive to these points, and that they will continue to give them their attention. From the remarks of Dr. Phillips one would almost conclude that he wishes us to practically abandon the planting of exotic trees in this country, but I do not think he can quite mean that. He also appears to be alarmed that the Forest Department might make the error of planting such trees and in such a manner as to cause the evil effects which he fears. But I do not think there is the slightest danger of their doing this. Now just to say a word or two about these exotics. I know to some extent the danger of planting them and causing a diminution of the water supply. But I think our Forestry Officers know better than that, and where there are places where there is a danger of a diminished water supply as a result of the planting of exotic trees, they will refrain from planting. But to sound a note of warning that we are to abandon planting exotic trees sounds almost absurd, if I may be allowed to say so. I would like to give one example. A man living at Kwambonambi in Zululand, on the flats, where practically no erosion can possibly occur, planted 2,000 acres of *Eucalyptus saligna*. At that place there is subsoil moisture, almost independent of rainfall, and I personally purchased that plantation from him 18 months ago, and I paid him £45,000. Well, that represents a considerable amount of revenue to this country, and I may say that the Company from whom I purchased the trees will also make a considerable sum of money, besides which it will aid considerably the industries of the country. In regard to wattles, which at first sight without looking carefully into the position, might be regarded as trees which would cause a diminution in the water supply, what I can state is this. As I said at the beginning of my remarks, I am on the research committee of the wattle growers, and I can give it as my evidence that on the estates which are now being managed on the system recently introduced by the Forestry Department of this country there is no run-off between the trees. I am sorry in my evidence to have to contradict Dr. Phillips, but I am speaking of what I have seen with my own eyes. I can state that as soon as they abandoned burning, and placed brushwood in rows apart, there has been no flow off. That

The evil of grazing plus the evil of burning is certainly very disastrous. Those who fear that plantations exert a bad influence will agree, I think, that it is far better to have plantations than to have grazing plus veld burning, or agriculture on very steep mountain sides. So that from the forester's point of view and as we see it today we feel that in the direct utilisation of these catchment areas forests have been more beneficial than agricultural pursuits. That of course is from the point of view of deriving direct advantages from the utilisation of the soil.

Now it is argued sometimes, though it is not a very strong argument I am afraid, that in regard to areas under forests or plantations,—and I take it we are now confining ourselves to these because that is after all our chief term of reference—that plantations may, as I have seen myself, cause erosion. But it is not the plantations themselves that are the cause of erosion. It is in much the same way as areas of grass land that will not cause erosion if animals are kept off, that a properly managed plantation will not encourage erosion. South Africa is full of examples of mismanaged small wood lots, chiefly in the hands of the private owner, who may establish a wood lot for the purpose of sheltering his stock. In course of time, stock will take shelter, and on the high veld and other parts of the country where these small wood lots are established, the result is, treading down the soil and destruction of the humus. So that in that particular instance it is not the plantation that is the cause of erosion, but the animals grazing there. The other day in the Kruger National Park, many of us I suppose were alarmed at what might happen there when game increased in numbers. Destruction of the vegetation due to over-stocking with game was visible in various parts of the area that we traversed. It looked as if we were asking for trouble in that respect. As the animals increase there, the vegetation is trodden down, heavy rain follows, and this no doubt causes an immense amount of sheet erosion, and the destruction of seedlings and trees. So that even if an area is left entirely to nature, in which case the biological factor comes into play, dangers are ahead. Take an indigenous forest, if it is mismanaged, it may cause erosion, and most of us have seen that, particularly on steep hill sides, so it is all a matter of management. A well managed plantation or forest is no doubt the best means of keeping our soil intact.

Then there is stream flow which is causing some serious alarm. I myself have no knowledge of any streams that have actually dried up as a result of plantations of exotics, I only know this from hearsay. But if that is the case, I can assure the Conference that there will not be very many cases that can be cited. But a vast number of other cases can be cited, both from my own personal knowledge, and otherwise—in fact everybody in this country will know of them—where streams have dried up as a result of mismanagement in the ordinary course of agriculture. We have many cases of that sort.

where streams have definitely dried up as a result of bad management. If there is anything in this theory of drying up streams by plantations, it may have an entirely temporary effect. If it occurs it is probably because our plantations are established by means of pioneer plants, that is to say, light demanding plants. In their earlier stages, they are no doubt exacting on these conditions, but speaking from my own experience as a forester, it appears to me that in regard to these so-called exacting plantations which will not even allow their own young to take shelter, under the wing of mother trees, after a certain period, probably towards the middle rotation, they become less and less exacting, I could quote many examples of that. For instance we have that voracious blue gum. We find that most of the forest floor is bare, and nothing will exist during the younger stages but afterwards ferns and indigenous trees make their appearance, showing that at this particular stage in the existence of the plantation the trees are not so exacting as when they started. Examples could be quoted *ad lib* and it seems to me that in course of time there will be many more examples to quote. It might in fact become the rule, and if this is so, and it is contended that streams dry up through the planting of plantation trees, these streams may become perennial again. I think one must be very careful and observe. One thing is clear, we must not become hysterical about these things. I myself have no doubt that a properly managed plantation (and I am referring to plantations continually) will do no harm. In regard to indigenous forests, we are all agreed, I think, that they would not perpetrate the evil deeds that our plantations are supposed to be guilty of. I maintain that the case against plantations soaking up moisture and preventing streams from flowing, has not been proved. I certainly do not think that plantations of exotics will cause erosion if properly managed.

It has been said that the time has come for a compromise between the forester and a nature lover. I do not know what this means. It may mean that the forester will have to compromise to himself. If at any rate, such compromise be called for, I think the facts of the case are that ours is not a free country. We will have a very small percentage of our area under trees at any time even if we increase our forest resources to the maximum. I should say that at least two-thirds of our forest reserves will never be planted with trees whether of exotic or indigenous species, because they are inaccessible and unsuitable, and there will be vast areas left for those who love to see the South African countryside clothed with its own indigenous flora.

Further in connection with this matter: I think it was General Smuts who referred to compromise. I am sorry I have not got the picture with me, but I remember a little while ago in one of the illustrated papers, the General was shown on the slopes of Table Mountain on a hot day, sitting down on a bed of pine needles under the shade of *Pinus pinaster*. In the picture one could see what

appeared to be a patch of wag-'n-bietie and protea bush, but the General did not take advantage of the seat of the wag-'n-bietie, nor of the shade of the fynbos, but sat under the pine trees. What better compromise could have been reached.

Mr. J. B. Clements (Nyasaland) : It may be of interest for me to mention that in Nyasaland, an important factor in the cause of desiccation and erosion is the physical change which takes place in certain soils after they are put under cultivation, and this particularly applies to lateritic red loams and ferruginous soils, which are very extensively distributed in the Protectorate. They soon become crusted, resulting in a very much reduced power of absorption, and an increased run-off of rain water during the short rainy season. Erosion is mainly sheet erosion, although the scouring out of stream beds has become serious in a few localities. Gullying is not wide spread; and is usually confined to a few localities where there is overgrazing, and in others where the soil is abused in primitive methods of growing finger millet. Ample evidence is available as to the drying up of streams following the destruction of forests, and other vegetation involved in native agriculture, which is to be discussed to-morrow. The reverse process has also been recorded. I may say I saw a reverse case of a stream flow coming back after a long resting period. There was a mission abandoned over 40 years ago at a place called Hora in the Zimba district of Nyasaland which is very dry. The natives cleared the ground by what we call the axe-and-fire method, that is, burning the soil to a very intense temperature, in order to get a thick crop, and presumably to get partial sterilisation. There is ample evidence, both European and native, that a fairly big area in that region was cleared entirely of vegetation. Hardly any vegetation at all was left. Grass disappeared, trees disappeared and the local water supply dried up. They moved the mission about 150 miles away, but after 40 years rest, the natives have started coming back, to the old spot. Open woodland has grown up again, and there is ground covered with acres of herbaceous growth. It was the late Dr. Laws who was 54 years a missionary in Nyasaland, and who followed Davis Livingstone, who pointed it out to me. He had been there, as I say, 54 years, and had seen these changes. That can be verified, and I saw myself the newly established villages and the revived water supply. In the formation of plantations, particular care has to be taken in the cultivation of those soils liable to crusting, which I have mentioned, otherwise increased erosion and run-off may be set up. In the case of even-aged stands, plant litter and humus usually prevent sheet erosion and soil crusting, but at present it is impossible to say whether as much moisture is absorbed by the soil under such conditions, as compared with those in which a low plant cover plays a part. One other point in that connection might be mentioned. About 25 years ago, at the Livingstone mission in the northern district, they installed a hydro-electric plant for the mission station,

and they were very perturbed about not getting a very good water supply, but following a scheme of afforestation, Dr. Laws assured me that they had got an increased stream flow, and the requisite power for the plant, and I believe it has been maintained ever since. They put down very large areas of eucalypts for the whole of the catchment locality. I can only give you the evidence, that the stream flow was definitely increased after the plantations had had about six or seven years of life, and I have not heard of any further trouble in connection with that power scheme since that time.

Mr. Nils B. Eckbo (South Africa): A great many speakers have spoken on the great benefits derived by mankind from forests, and the inevitable disaster following forest denudation. As far as I could gather from Dr. Phillip's address, he was in agreement with those views, when applied to the countries concerned, as well as to those parts of this country covered by indigenous vegetation. I stand open to correction if I am wrong, but I think Professor Phillips condemned the introduction of exotic trees for two reasons, namely, they use more water, and in some cases they cause erosion. But I would point out that no data was submitted in support of these contentions by Professor Phillips, and he furthermore stated in his address that no one for or against has enough evidence at present. In spite of this inadequacy, he urged the curtailment of afforestation for possibly 20 years until these points could be proved. In regard to water consumption by exotics it is inconceivable to my mind that this could possibly be of such proportions as to outweigh the great advantages of a national wood supply which are too numerous to mention.

The plantations inspected at Coetzcestroom, Berlin, Tweefontein and Graskop, had exceptionally good soil cover in the shape of organic matter precluding any tendency to erosion, and judging from other plantations as well, I can only conclude that those instances known to Professor Phillips must be of such rare occurrence as to be negligible. There would seem, therefore, no good reason to retard in any way the almost phenomenal success of one of South Africa's best crops at present, but I would heartily support all necessary research, as well as all possible expansion of the indigenous forests, because of their botanical interest and tremendous sentimental value.

Mr. H. A. Garland (India): In opening this debate Mr. Trevor referred to the remarkable destruction that had taken place in India and other countries by the denudation of forests. My sole excuse for occupying the Conference is that I should like to augment what he said with a few facts, referring to a case in India where it was found definitely possible to check erosion and to improve soil conditions by good treatment. Before giving those facts, I want to emphasize that point of good treatment. A negative policy of no treatment is definitely found to be useless. Certainly in the Presidency which I come from, that is Bombay, and I think possibly elsewhere, forestry conservancy in its early years was rather too

inclined to a negative policy. That is to say, they said that simply stopping grazing would be sufficient, that the tree growth would come in again, and we should be able to clothe our bare hillsides with what we wanted. Unfortunately, although that might have been the case in the course of years, the process was excessively slow. Denudation and the general destruction of vegetation had gone so far that the process of reconstruction was extremely delayed, indeed almost invisible. Whether land is best utilised as forest or pastures is a matter of ecological status and economic conditions and the basis of such utilisation must be a detailed survey and careful land classification.

Now to turn to this particular instance, of which I wanted to give a few data. At Poona, which is the summer capital of the Bombay Presidency, we had an area of about 40 acres, which the Forest Department had fenced and closed to grazing. The area remained closed I believe for about 40 years, and the result was almost negligible. The climatic conditions were that there were about 24 inches of rainfall, and the area was situated on the tension belt between the thorn scrub and mixed deciduous forest. The vegetation consisted chiefly of thorn species with a few very scrubby mixed deciduous species, and a great deal of the very inferior grasses, the *Aristidas*, *Andropogon contortus*, and so forth. There was a definite amount of erosion which was steadily increasing. This erosion was creeping up the small nullahs, or the dongas as you would call them in this country. It was gradually creeping up the hillside. Then, in conjunction with the Agricultural Department, we started an experiment of controlled grazing in this area. The Agricultural Department also built small stone walls, very low indeed, along the contours in places where there was any sign of erosion and divided the area into paddocks. First of all, in the first year, they put ten cows into this particular area. After about three months the poor things were so hungry that they jumped out and ran away. They then divided the area into four paddocks, three of which were grazed in rotation, and one kept for cutting grass and making hay. When I say in rotation, there was no fixed rotation at all. The animals were simply moved from paddock to paddock, as the grass was used up. They were grazed as closely as possible in each paddock and then moved on to the next. Well, the result of that treatment in five years was that they were maintaining on that particular area 20 cows throughout the whole year in very fair health indeed. But the point which is of particular interest was that the vegetation had been definitely improved. The *Aristidas* and the other inferior grasses had almost entirely disappeared, and very much better grasses such as *Anthistiria ciliata* and *Andropogon pertusus* had taken their place over the entire area. But it did not stop there. The forestry object was also being achieved. The state of vegetation and succession had been so much improved that in spite of this very heavy grazing, the natural regeneration of our mixed deciduous

species and particularly the *Terminalias* began to make its appearance. Moreover erosion had been checked. So that in five years we had reached the stage in which the soil had been so much improved that it would be possible to decide on the economic point of view, whether we desired to carry on with our natural vegetation and turn it into a small fuel supply area, or whether it was desirable to assist the milk supply of the city. For a small scale experiment I think the Conference will agree that it is interesting, and the details have been published in a bulletin by the Bombay Agricultural Department.

Prof. John Phillips (South Africa): I fear that in my talk the other day, I must have failed to make myself perfectly plain, judging by the impression that has been picked up by Mr. Wilmot, which has also been referred to by Mr. P. C. Kotze and Mr. Eckbo. I think in my statement to the Committee on the Forest influence, I did make this point clear, and I think I also made it clear the other day at Berlin Plantation. The point at issue is this, I did not suggest that afforestation with exotics in South Africa should definitely be held up. Anyone who made such a claim would be speaking quite irrationally. One realises perfectly well that trees have to be grown for economic purposes. What I did attempt to plead was that we should exercise care as to where these exotics are established—that is the water demanding exotics, such as the eucalypts, the wattle and much lower down the scale, some of the pines. I want to emphasize this point, because it makes all the difference between an apparently very extreme view—almost hysterical view—and the point of view that it is well worth while to look into this matter of probable soil deterioration and excessive water consumption. We heard on Wednesday afternoon of several examples. I remember some were mentioned by Prof. Troup regarding the suspected influences upon soils of pure stands of conifers, I believe in Saxony. And other examples could be cited. I have put forward these views and suggestions in the hope that they will arouse foresters to look very seriously into the matter. I am sorry, if through my inability the other day to make these things clear, I should have caused any misunderstanding in the minds of those persons who listened to me. Unfortunately, this caused Mr. Eckbo to believe perhaps that I had made a very definite attack on afforestation in general, but I have not done that. I have simply asked for an investigation and have suggested in the meantime, that areas of paramount importance, whether large or small, and whether owned by the State or private individuals, should not be planted with fast-growing water-demanding exotics if water supply in that area is of the first importance.

Mr. H. M. Gardner (Kenya): In all these discussions on forest influence we are all very seriously lacking in authentic records, and it seems to me that we have in South Africa a very good chance of

obtaining really accurate data of the effect of forests on water supply. I remember when in New Zealand, I made a suggestion to the New Zealand Forestry Department at Rotorua, that in view of the very extensive planting work being done in a treeless area there was a great chance to start a series of rain gauges to see if this vast area of new plantations had any effect on local rainfall. They admitted there was a good opportunity, but apparently they had so much rain in New Zealand that it was of no practical interest to them. But in South Africa, I think there is an excellent opportunity in connection with such catchment areas as the Sabie and Weza Plantations, where there are a number of small streams, of obtaining invaluable records of the effect of tree planting on run-offs. I suggest that a definite and comprehensive scheme of stream gauging should be adopted in all afforestation areas, by the Irrigation Department and Forest Department in collaboration. Then we should have records, not only of great value to South Africa but to the world as a whole.

Mr. Trevor (India): In the course of this debate you have listened to the experiences of members of this Conference in various parts of the world, and you have been given instances from history of the results of the destruction of forests on the civilisation of man, and the fertility of the land. Mr. Galbraith dealt with the importance of the Murray River catchment area, which is the source of a very important irrigation scheme on which the prosperity of three states in Australia will depend. Mr. Keet dealt with the desiccation of the country—from the standpoint of South Africa—which is so apparent to many people who have lived in this country for many years. He stated that rivers which at one time had hippo-pools in them no longer possessed these pools. Mr. Ainslie dealt with the very serious wind and water erosion in Nigeria—its effect on the savannah forest there, and the degradation of soil which has resulted from the various destructive habits of the people such as fire, grazing and cutting, so that countries which were at one time prosperous and carried a large population, and a certain amount of civilisation, have deteriorated, and the land had practically become a desert. Mr. Finlayson dealt with the sand dunes formation along the banks of the St. Lawrence River, which I have seen myself. In the early days farms were cut of the forest, and these were succeeded by the formation of sand dunes, and now mankind has to rebuild the former conditions at considerable expense. He also dealt with the decrease in stream flow of the St. Lawrence River—one of the chief waterways of the world. He also drew attention to the fact that afforestation on the Elbow River had had a beneficial effect. At one time there was very little water there and now, when trees have come up again, the stream flow has been revived. Professor Phillips has warned us as to the effects of planting certain water-demanding trees in a country like South Africa, but from what he has just told us I do not think he has much disagreement with most of the members.

of this Conference. He simply states that we should be careful where water supply is of paramount importance as to what type of vegetation we use—for the conservation of that water. I think therefore that I am correct in quoting Prof. Phillips that the main point of his argument is this: he does not dispute the fact that forests have an excellent influence on erosion of the soil. He merely wishes to point out and emphasize that especially in the case of the eucalypts and possibly acacias, and to a less extent in the case of pines, we should not do anything in this direction until we have full knowledge of the subject.

In my opening remarks I stated that erosion was due to the mismanagement of the soil—whether it be by destruction of the forest by fire, by excessive grazing, or whatever it might be—I think that we are all agreed that the fundamental causes of erosion, which are so serious throughout the world, are the mismanagement by man of the resources placed at his disposal by a bountiful nature.

In dealing with the management of the land, it is no good saying that if land is left alone it will do all that is necessary. That no doubt is quite true, but man does not live by scenery alone. Man must exist: he must produce crops for his sustenance, and timber to build houses and for other purposes. Therefore what we are concerned with is a reasonable management of the land, whether it be forest land or wattle land, agricultural or grazing land. If you can only have reasonable and proper management of the land surface the problem of erosion would be solved. But unfortunately we who may recognise these evils and their remedies have to deal with a large body of opinion, often ignorant, which is not prepared to accept what we may say, or even if they are prepared to accept it they are not prepared to be restrained in any way from the destructive practices to which they have been accustomed. One of the best things that we, in co-operation with the agricultural officers, can do is to try and preach the gospel of a reasonable and efficient management of the land. I think one of the most important arguments which have been put forward as supporting our contention for the benefit of forests was the remark of Mr. Thornton that trees diminish the force of winds and thus mitigate sheet erosion and slow down the water flow of a given area, and in irrigation matters that is of supreme importance. Great floods of water come down from the hills but they are of no use. The water does not penetrate into the soil and cannot be utilised in large volume. It silts up the dams, ruins the irrigation works, destroys the railways and does untold damage. If forests can merely slow up these floods that alone is of inestimable value to mankind. If you were to consider the cost to the engineering departments of the railways of the world and other bodies on account of repairs that have to be made due to floods, all the money spent on forestry throughout the world would be a mere drop in the ocean. We have had this statement made to

us by Mr. Roberts of the Irrigation Department. He has told us that he entirely supports Mr. Ainslie's statement that erosion was worse in areas of low rainfall, where the roots die and the surface of the soil is blown away, and that he preferred natural forest in such areas where water supply was of paramount importance, and I think that we as foresters would not do our profession any harm if we subscribed to that statement until such time at any rate as the contrary has been proved.

Mr. Hunt Holly also gave us his opinion, founded on great experience that the proper management of the wattle industry had had no bad effect on the soil: that erosion on his land which we ourselves have seen, was non-existent, and that the planting of that large area of wattles had had no ill effect on the water supply on his farm. He moreover pointed out that on his neighbour's land which was largely unplanted very serious effects from floods had been experienced over a series of years. Mr. McKenzie told us that he had more water than before.

I do not think it necessary to go into all the statements which have been made here: they all more or less bear out the general statement that afforestation has a remedial influence on stream flow, and on erosion, and if that is so we are doing a great deal of good in the world in trying to get as large areas as possible of suitable land growing trees instead of rubbish. (Hear, hear.)

I think therefore I may sum up the whole trend of the debate by saying that we attach great importance to a thorough investigation of these many problems which have been placed before us. We have an opportunity now in co-operation with eminent men—agriculturists, engineers, botanists—and others, in regard to this matter about which a certain amount of controversy has arisen, but when all things have been boiled down really very little controversy in fact exists—we are all agreed that a really thorough series of investigations should be carried out in co-operation with all interests concerned, and extending over a series of years on this important question. (Hear, hear.)

The Chairman: That will close this discussion on Forest Influences, and it will not be heard again in plenary session, until the committee stage.

(Conference adjourned at 6 p. m.)

SEVENTEENTH SESSION, SATURDAY, 5th OCTOBER.

HELD IN THE NEW LAW COURTS, CAPE TOWN, AT 9-30 A. M.

Chairman: We come now to the consideration of the reports of the committees. It is necessary that this work should proceed expeditiously and also that thorough consideration be given to the reports

because they and the summary report of the Conference and the Resolutions form the permanent record of our work. In order to expedite business I suggest for your approval that we do not attempt drafting amendments, that is to say verbal amendments to reports. Instead I propose this procedure, that when a delegate has a suggestion to offer either in the wording or on the sense he should state so in so many words without attempting to amend the text. It will then be the business of the Chairman of the Committee to take note of that suggestion, to state whether he can incorporate it in his report, and, if so, to revise his text accordingly. Is the procedure agreed? (Agreed.)

We will proceed then with the second reading of the Companies' reports. The first reading we take as having been accomplished with the circularisation of documents. There will be a third reading on which the Chairman of each Committee will report the steps he has taken to give effect to the wishes of the Conference.

REPORT OF THE COMMITTEE ON FORESTS IN RELATION TO CLIMATE, WATER CONSERVATION AND EROSION.

Mr. Trevor: You have before you the report of the committee over which I have the honour to preside. I do not propose to repeat all that has been said in debate on this subject but I will confine myself more or less to the actual work done by the committee, as certain aspects of the matter were brought to our attention which were not discussed in full at the plenary session of the Conference. At the beginning we have endeavoured to place on record the effect of forests on various factors such as temperature, rainfall, wind and humidity which sum up climate and there can be no question, I think, for the evidence shows that forests have an ameliorating effect on climate, that they have tended, if anything, to increase local rainfall and to increase the humidity of a climate. As regards rainfall, you will see from what we have said, that we are not prepared to endorse any wild statements that have been made, mostly by people who are unacquainted with the subject, that forests increase rainfall. They say all you have to do is to plant a few hundred acres of trees and you will have an increased rainfall. That is absurd. You will find we have dealt with this subject in a judicial way and I am convinced that on the evidence existing throughout the world forests certainly have an ameliorating effect, at any rate locally, on the rainfall. To pass on to the next important part—the relation of forests to water conservation—we have had the benefit of the views of several distinguished gentlemen who appeared before the committee and spoke to us regarding their personal knowledge of various subjects. We had Mr. Lewis, Director the Irrigation Department, Mr. van Reenen who was on the Drought Commission and we had Mr. Thompson who has made a detailed study of the rainfall of South Africa. The views of these gentlemen were not before the Conference.

but the committee have in their report made use of what these gentlemen have said. There is another thing you must be aware of. It has been very largely stated in the press, resolutions have been moved in the House of Parliament, regarding the very precarious effect of tree planting on the local water supplies of South Africa. Several gentlemen approached me and other members of my committee and were most emphatic that the planting of a few hundred acres of pines had dried up the water supply and were doing irreparable harm. I have no doubt whatever that such statements are entirely untrue. On the other hand, we have been driven to take very serious notice of these statements. When a man tells you that a stream which gave water every summer and does not give water since the Department have planted trees, you have to take notice of that. A definite statement of fact is made and I think it is the business of the Forest Department, whatever little value they may attach to such statement, to prove that conditions in South Africa follow the general conditions throughout the world and show that forests are beneficial in conserving the water supply of the country. We have advocated in our report that a really scientific inquiry should be carried out to disprove some of these wild views. We have had the benefit of complete rainfall statistics from the very beginning placed before us and there is no doubt generally that there has been throughout South Africa for the past few years a decrease in rainfall, and I think it is only fair to attribute any decrease in water supply primarily to the fact that rainfall has very largely decreased. But we feel that it is not sufficient merely to state that all over the world forests are beneficial to water supply but that the problem should be properly investigated in South Africa and any results obtained in South Africa will be of very great benefit throughout the world. If you will turn to the subject of erosion; a great deal was said on this subject during the debate. There is a mass of literature on the subject, and there can be no question whatever that the destruction of the natural soil covering of the earth has had a most appalling effect on the world. We have instances where the destruction of the forests has entailed the most appalling consequences. We know, also, it is not a question of forests only, but also a question of other natural covering of the soil, such as veld, ordinary grass veld, or this heath vegetation of the Cape Province. The effect of burning of excessive grass and bad agricultural methods result in the destruction of the natural soil covering, and only too often, once that cover is destroyed, we have erosion and general deterioration in the value of the land. That brings me next to the question of veld-burning. We were particularly requested to deal with this matter. You say this is a matter which does not concern foresters, but, gentlemen, foresters are as deeply interested in the subject of grass-burning. You are all aware that the practice of burning the forests practically throughout Africa has been attended

by very serious consequences. You will have listened to what Mr. Ainslie has said, and there can be no question that generally all forms of grass-burning are, from a point of view of conservation, deleterious. On the other hand, it is no good taking up the point that grass burning is bad and should be abolished. It is essential, not only in South Africa, but in many parts of the world, to get rid of this vast accumulation of dead grass which results from a summer rain. You have plenty of keep during a few months of the year with which the cattle cannot possibly cope, and then you are left with a large accumulation of dead grass which has to be disposed of, and burning under most circumstances is the only possible way to deal with it. But if you have to burn, there is every reason that you should burn under the most carefully controlled conditions, and at the right time of the year, burn to the extent necessary to fulfil your requirements, and burn in a scientific manner. The indiscriminate firing of the veld and mountain ranges has caused a considerable amount of harm and has hastened the process of erosion. In conclusion, we have endeavoured to deal briefly with the subject, we have reviewed in a general way the great question of veld-burning and we have considered the complaint made to us, and the effect of afforestation in South Africa, and I think you will all agree with me, gentlemen, that the policy adopted by the Government of the Union of South Africa in pushing forward afforestation, and the way in which it has been carried out, have been of enormous benefit to South Africa. We have seen miles and miles of plantations, we practically motored through them from morning to evening, and no one looking at these areas of plantations and realising the money which had been spent on them in the way of labour, and the future benefits which can be derived from them, can fail to recognise that a most excellent work has been carried out in this country.

The Chairman: With Mr. Trevor's introduction, I propose to take the report either page by page, or in sections according to the desire of the Chairman of Committee. The Chairman will take note of everything said and will say when a point is raised whether he will accept it. The Report was then taken in short sections and adopted with some few modifications.

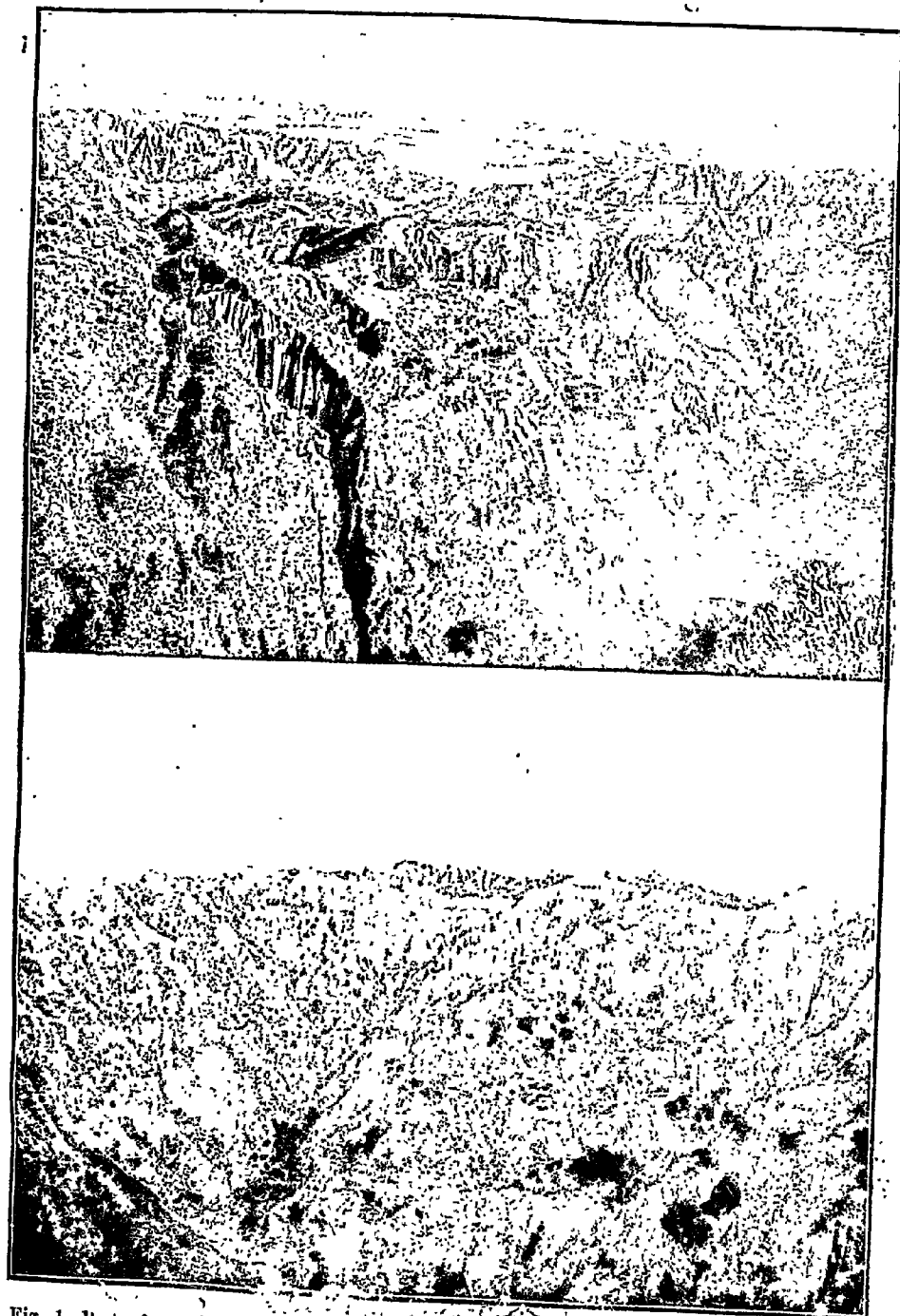


Fig. 1. Part of S. range with *cho* (torrent) in

Fig. 2. Where sheet erosion and run-off reach a *cho* (torrent).

grazed slope end of

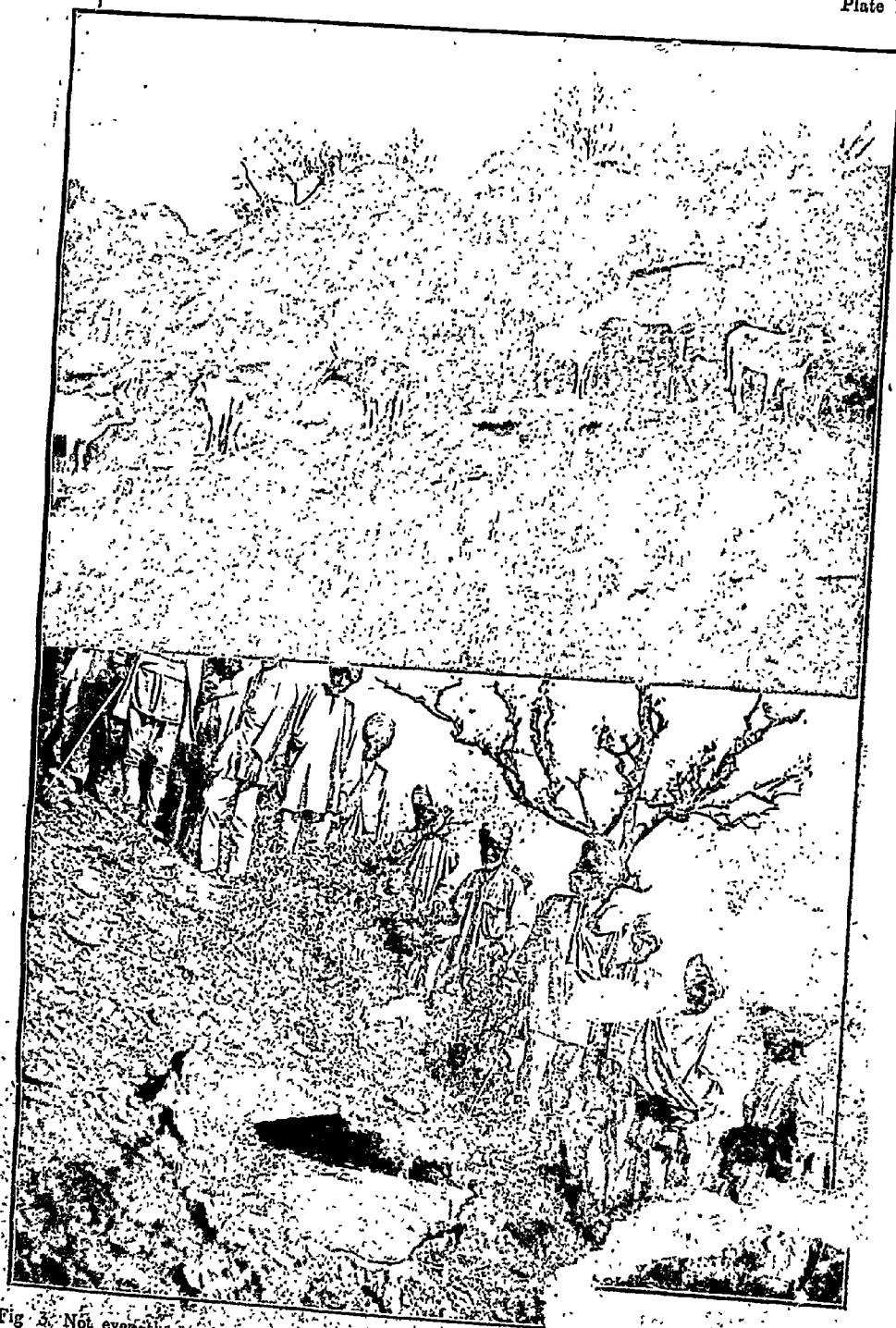


Fig. 3. Not even the steepest slopes are left.

4.

top

end of

Soil Erosion in India and its Consequences

BY

H. M. GLOVER AND A. P. F. HAMILTON.

The sub-continent of India is of such vast extent and conditions are so varied that a detailed description would be beyond the scope of this article. Nevertheless it is necessary to form a general idea of the climate, the geography, the population and its customs in order that this paper may be intelligible.

Peninsular India consists of a peneplane of ancient geological formation with low hills, still partly covered with forests which extends over a large part of Central India, and is separated from the Himalayas by the flat and low-lying plains of the Ganges and the Punjab. To the north the Himalayas form a rampart rising steeply from the plains and separating India from Tibet.

The climate is sub-tropical in the plains, where the heat in the summer is intense, but in the Himalayas much pleasanter conditions are met with. The cold season is of short duration except at very high elevations.

The rainfall varies from almost nothing in the desert tracts of Rajputana to over 100 inches in the outer Himalaya and is profoundly affected by elevation and the distance from the sea. Over half the annual rainfall takes place in July, August and September during the summer monsoon; April and May are dry and intensely hot; the autumn is dry and in winter very little rain falls. Towards the north-west the rainfall decreases and the Punjab, formerly desert, is now irrigated by a network of canals which take their origin from the rivers of the Himalayas.

Throughout the greater part of India the population is predominantly Hindu to whom the cow is sacred, never to be destroyed even when old and decrepit. As a result every village possesses large herds of cattle entirely disproportionate to its needs, and far beyond the capacity of the country to support. No land is set aside as meadows and as much of it as can produce cereal crops is cultivated, and the cattle graze in the waste and in the forests, all the herds of the village being in the charge of small boys or herdsmen. As a result the cows are ill-nourished and undersized; only in the densely cultivated alluvial or irrigated lands are the animals stalfed. The population throughout the cultivated tracts is dense, reaching even, in some cases, 1,000 persons per square mile in the rice lands of the Ganges valley. The holdings are small, often not exceeding three to five acres per family. The density of a peasant holder's lands are divided amongst his sons, and the fragmentation of holdings is probably greater throughout India than in any other country of the British Empire.

Goats are kept universally and browse on stunted bushes and herbs where cattle cannot pick up a living, and thrive in the drier tracts. In addition to the above resident animals there are large migratory flocks of sheep and goats, particularly in the mountains of the Himalayas where they graze in summer in the high lying alpine pastures and in winter in the scrub forests of the low foothills. Buffaloes are kept by nomadic graziers particularly in the low foot hills of the Himalaya and would roam unchecked through the forests and alpine pastures of the Himalaya were it not for the stringency of the forest laws. Broad leaved trees are universally lopped for fodder, and except in reserves or in forests closed for reproduction there is little opportunity for seedlings to become established.

The pressure on the forests of the population both human and animal, is intense and is increasing. The irregular distribution of the rainfall and the intense summer heat and drought cause conditions over large tracts of country which make it difficult for vegetation to persist, and as the grass dries up during the summer the animals browse on the bushes and herbs thereby reducing the covering to an extent which exposes the soil to severe erosion during the heavy rains of the succeeding monsoon.

Conditions had already in 1855 become so acute that it was necessary for Government to promulgate rules for the management of restriction of cutting in the hills. These rules were followed by forest settlements in which portions of the forests were set aside as Government reserves or protected forests and the remainder was allocated as village forest or grazing grounds, generally with simple restrictions as to rights of user or often none at all. The rules of 1855 were followed by the constitution of a special forest department and by the promulgation of the Indian Forest Act with the result that most of the more valuable forests set aside as reserves are in good condition, but that of the village waste is deplorable. Everywhere the village forests are over-grazed, ruthlessly felled and are deteriorating. As the cover of trees, bushes, grass and herbage is removed, the soil is washed away, and in the north-west of India the situation is causing anxiety to the Government.

It will be of interest to discuss in considerable detail the conditions prevailing in the Punjab in the tract bordered by the outer ranges of the Himalaya. To have a proper understanding of the important part that the conservancy plays as a factor in the prosperity of the Punjab it is necessary to realise that the bulk of this province is a continuation of the desert which stretches unbroken to the eastern shores of the Mediterranean. The Punjab plains are rendered cultivable only through the agency of great irrigation schemes. The outer slopes of the Himalayas do, indeed, come under the influence of the monsoon rainfall but the monsoon weather is modified by short and sharp bursts of rain occurring after long

intervals. Under these conditions it is obvious that once the vegetation has disappeared owing to over-utilization, it can only be replaced with extreme difficulty. It is also obvious that the presence or absence of vegetation on the hillsides must have a profound hydrological effect on stream-flow. That these low hills have been consistently over-grazed for many decades is unquestionable. In the Siwalik hill tracts of Hoshiarpur district the average grazing per head of cattle is only about 2·5 acres, and this figure is probably representative of conditions throughout the greater part of the low hills. This is an absurdly low figure as compared with what is considered a normal grazing incidence in Europe or America. Against the consideration that the Punjab hill cow is a small animal, it must be pointed out that the grazing is generally so poor as to consist only of isolated tufts of grass, often of unpalatable species.

The gradual deterioration of grazing has compelled the herdsman to exploit other means of feeding his cattle, and broad-leaved forest has been lopped practically to extinction. The destruction of tree growth reacts unfavourably on grazing capacity in two ways; firstly, deprived of shade, the quality of the grass on the hot slopes deteriorates; secondly, erosion, which results from the removal of the vegetable covering causes a direct increase in the grazing incidence. Thus a vicious circle is established, as a result of which floods, desiccation and destruction of cultivation have appeared.

This general description of conditions in the Punjab has been given in order to explain the origin of erosion in the low hills and to show how complicated the problem is. It is now proposed to describe in more detail the nature of erosion and its consequences, and as an illustration, the case of the Siwalik hills in Hoshiarpur district will be taken. These hills form the northern boundary of a rich alluvial tract; the range extends, in this district, for 85 miles is about 8 miles wide and, at the most rises 1,000 feet above the level of the plains. The mean elevation of the watershed above sea level is about 2,000 feet. The southern slopes are formed mainly of soft, friable sand-rock which can be broken off by the hand; the northern slopes consist of soft, earthy beds mixed with shallow strata of loose conglomerate. Since the histories of deforestation and erosion of the two sides of the range differ considerably, they will be dealt with separately.

The foot of the southern slopes borders directly on to the rich cultivation of the Hoshiarpur plains. Owing to the softness of the rock, the action of water has fashioned in the hills a complicated network of deep ravines and gullies, thus forming catchment areas of a size altogether out of proportion to the exterior configuration. The slopes are often steep, and the soil is unsuitable for cultivation. Before the advent of the British these hills were the property of chieftains who still preserved the forested slopes in the interests of sport. There is reliable evidence that the hills were well wooded

in those days and that perennial streams issued from them into the plains where they followed defined channels. At the first land settlement under British rule in 1852, the Siwalik forests were written down as "scrub forest and brushwood not worth preserving" and almost anyone in the neighbouring villages who presented a claim was given full proprietary rights in the forests.

Under British rule a period of prosperity and development began. Population increased, railways (which then burnt wood fuel) developed, cantonments were established and the demand for firewood and charcoal was greatly extended. The improvident landlords wasted no time in getting what they could out of their newly acquired property; large areas of forest land were leased out for a few rupees to contractors who had a free hand to fell all the trees they liked. Cattle-herding, formerly a rather risky source of livelihood, now became safe and profitable. Herds were grazed on the hills in increasing numbers and goats in particular swarmed everywhere eating down all shrubs and bushes and preventing any fresh growth from developing. In less than 30 years destruction was complete and, to quote from a report of Mr. Baden-Powell, Conservator of Forests, made in 1879:—

"So great has been the destruction that one may march for miles and miles with nothing in view but mud-coloured crests and rugged slopes, rarely dotted with greyish browsed-down bushes....."

Nature was not long in taking revenge on this abuse of her gifts. As disforestation proceeded, reports of increasing floods and destruction of land and villages came in. Along the 85 miles front of the Siwaliks some hundred torrents, or *chôs* as they are locally called, annually discharged floods of water and sand over the rich plains below. But the direct loss of cultivation by water action was little as compared with that caused by the enormous quantity of sand carried down in suspension. At an early stage the original stream-beds were filled up and subsequent floods, spreading far and wide, deposited layers of sterile sand over the surrounding lands. The destructive action of these *chôs* appears to have reached a peak somewhere about 1890. Subsequently there has been a gradual decline, mainly due to the fact that the force of the torrents is partially exhausted in covering the wide expanses of sand. But the *chôs* do not run out into any main drainage channel, and so all the degraded material is continually being deposited in the beds which must continue to rise until the water comes down clean. Therefore, until the catchment areas are again covered with vegetation, loss of cultivation will continue. The loss of cultivation has been great; accurate figures are not available, but not less than 150,000 acres have been converted into sandy waste, while the fertility of surrounding fields has been reduced by deposits of windborne sand. No longer do streams of water flow from the hills, the torrent beds are dry throughout the year, except during the

summer rains, when floods of short-lived duration rush down from the hills. The bare hills no longer retain the rainfall and, as a result, the water level in a zone two or three miles from the foot of the hills is sinking and wells are rapidly drying up. The destruction of the forest in the hills has meant the loss to the villagers of a property which under proper management could have brought them, in perpetuity, a steady revenue from fuel and other forest produce, and even of timber, for the lower slopes of the ravines can support good tree growth. Owing to the exposure of the bare sandy slopes to the hot sun and burning winds, now only coarse species of grass can survive, and the grazing even has deteriorated and with it the quality of the cattle.

In all about one thousand villages have been affected and the prosperity of the inhabitants seriously reduced. Government has also shared in the loss as the annual loss in land revenue is considerable, while many grants in canal colonies have been made to compensate villagers for loss of land. Money has been spent on fruitless engineering schemes to stem the torrents. It was not until 1902, when the harm had been done, that Government took action. Legislation was enacted by which sheep and goats were evicted from the hills and the utilization of forest produce restricted to the satisfaction of domestic and agricultural requirements. Unfortunately no scheme for reforestation was considered, and 32 years of protection, which did not include the prohibition of lopping and brushwood cutting, or introduce any form of pasture-management, have proved inadequate.

In 1932 the Punjab Government appointed a committee to report on erosion and to make recommendations. As a result a forest officer was deputed in 1934 to take charge of protection and reforestation works in the Hoshiarpur Siwaliks and a definite policy has now been decided upon. It is obvious that the usual methods of counter-erosion and reforestation are impracticable in these hills, as, owing to the extreme friability of the sand-rock and the enormous quantities of sand degraded, terracing of the slopes and training of the small ravines by bunds is impracticable, apart from the prohibitive expense. The ground has long been bare and no soil remains, for these reasons the establishment of forest growth either by natural or artificial means is very difficult and will be protracted over a long time, even with total prohibition of cattle-grazing. In order to render torrent-training and reclamation in the plains possible, the first essential is to hold up the sand. Experience has shown that a light covering of trees and bushes is not sufficient to stop "sheep" erosion of soft sand-rock, nor is it capable of forming a soil or humus layer *in situ*, because sand-rock breaks up directly into the fine grains of which it is composed and these are at once removed by wind and rain.

Such are the difficulties; a means of checking erosion must be found which can both rapidly and cheaply be extended over the

large area of bare and broken ground which has to be dealt with. By closing the slopes to cattle and thereby allowing a crop of grass to spring up, it is believed that this object can be attained to a very fair degree. The value of a good covering of grass in checking "sheet" erosion is well-known, and the first step contemplated, therefore, is to extend progressively a system of closure to cattle-grazing so that the hills are converted into a large fodder reserve. This is to be effected, as far as possible, through the co-operation of the people, compulsion being resorted to only where absolutely necessary. There are many difficulties, the chief being that of persuading the people, who are by nature graziers, to give up their ancient custom and to substitute stall-feeding for it. Fortunately a few villages have already realised the value of closure and they have demonstrated that the hills can produce a crop of grass which, although not of good quality, can be more than sufficient in quantity for their own requirements and that any surplus can readily be sold.

But grass alone will not solve the problem, it will appreciably reduce erosion, but owing to the fact that it must be cut annually for fodder, it will not have much effect on run-off and still less on the production of a sponge-like forest soil. Indeed this latter is only possible here under cover of a dense canopy.

The climate and soil conditions are such that torrents cannot be entirely stopped. Their force can be mitigated and erosion brought under control by covering the hill-sides with a vegetation consisting of grass and bushes under a light canopy of trees. Given complete closure to grazing Nature will, in time, do much to heal the sores, but some artificial aid will probably be necessary.

Experimental work in the training of the torrents in the plains has only just begun. It is a matter of extreme difficulty. The beds are practically flat, though tending to be convex owing to constant silt deposition. They vary in width from nearly a mile to less than a hundred yards, and the direction of the main current constantly changes from one side to the other. Sand is an unfavourable medium for engineering works, and could works be constructed, there still remains the question of the disposal of the sand brought down every year by the torrents. There is little hope until erosion in the hills is controlled. But reclamation of the sandy wastes now free from torrent action is being undertaken. The scheme involves complete closure to grazing. The sand is not completely sterile and can grow grass and trees, particularly shisham (*Dalbergia sissoo*) which grows rapidly and is useful both for timber and fuel. In this way the sand will become fixed and there will be additional sources of profit to the villagers. Ultimately these wastes will become cultivable. Since the surest way to form stable sand-banks is to fix them with vegetation, this method of reclamation may also ultimately provide a means of training the torrents.

Reclamation and consolidation will proceed inwards from both sides as conditions improve in the catchment areas, until finally the torrent bed is canalised between tree-lined banks.

The case of the southern slopes provides some peculiar features, on the northern slopes the process of destruction has proceeded more slowly and is probably fairly typical of what is going on in many parts of the outer Himalaya of the Punjab. The slopes are, to some extent, cultivable and the local population has increased. Owing to the absence of markets, disforestation has been protracted but is now practically complete. The truly cultivable land can not support the population, goats are kept by the poorer people to pay land revenue, no trees are left either for sale or for domestic use, and shifting cultivation on the steeper slopes is becoming a habit. Shifting cultivation implies the tilling of the steeper hill-sides without terracing, in two or three years all the soil is washed away, a top-layer of pebbles remains and the area is abandoned. In this way not only is potential cultivation destroyed, for the land could be made permanently cultivable if properly terraced, but so much grazing is also lost, while the denuded areas act as so many *foci* for erosion. At the same time erosion is gradually sapping into the permanent cultivation which has been long established on the ridge tops. Thus a vicious circle operates, for, as the village estate as a whole becomes less productive, so, in the scramble to get more out of it, the destroying forces spread over a wider area. Since the population is bound to increase in the future there can only be one ultimate solution to the problem, the incidence must be reduced to that which the land can support. This may take place automatically, or grants of lands elsewhere may have to be made. In the meantime protective measures can be taken and many of the people now realise their necessity and have applied for action by Government. Goats will be entirely evicted and this alone will allow the browsed down shrubs and trees to grow up and spread on the slopes not yet subjected to shifting cultivation. As a result of the partitioning of the land between the numerous proprietors, areas, set aside for grazing are often hopelessly mixed up with cultivation and closure on a large scale is impracticable. In such cases the only hope of improvement lies in persuading the villagers to make small closures of their own, each in his own property. This practice is not unknown in these hills and there seems a chance of extending it. The soil is very favourable for tree growth and so serious is the shortage of fuel and timber that, with help and education, a fair measure of success seems probable. It is equally important to stop shifting cultivation and to substitute for it well terraced fields. This will not be easy to do, but it is absolutely necessary, and with patience it can be accomplished.

Disforestation and erosion have caused torrents on this northern side also, and although a good deal of damage has been done to cultivation in the lands below, it is not as serious as that caused in

the plains by the *chōs* emanating from the southern slopes. On the northern slopes the torrent beds are steeper, the degraded material consists largely of small pebbles, and the floods find exit in a wide valley running parallel with the range. In 1927 the revenue authorities estimated that the torrent beds covered an area of 50,000 acres. But this figure does not include any loss of land by erosion in the hill tract, and this must be considerable. There are many villages in the hills and in most of them the water-level is sinking and there is an acute shortage of water.

This is the case of the Hoshiarpur Siwaliks. Excessive grazing and lopping is the root cause of erosion. In the Punjab there are over 25 million cattle, including browsers. Of the 6,695 square miles of the forest area under the Forest Department, 6,252 are open to cattle grazing but only 12·9 per cent of the animals are admitted to this area, the remaining 87·1 per cent have to exist on the village forests or on the produce of arable lands. The deterioration of the village grazing grounds will eventually result in agitation by the villagers for further concessions in the protected and reserved forests, and already in many of these conservancy is difficult enough owing to the heavy incidence of rights.

For over half a century the Forest Department has pointed out the necessity for introducing forest and pasture management in the village forests in the low hills. Apart from recent attempts in Hoshiarpur, action, if it has been taken at all, has been tardy and half hearted, or has been entrusted to those who are not versed in these matters. Village reconstruction is now receiving much attention; the hill villager depends for his livelihood on grazing and forest produce; surely therefore, a plan of reconstruction should include, as one of its most important features, the reconstruction of the village grazing and forest lands.

